# 1997 ACE PLAN

# AVIATION CAPACITY ENHANCEMENT

U.S. Department
of Transportation

**Federal Aviation
Administration**

# 1997
# Aviation Capacity Enhancement Plan

## Federal Aviation Administration
## Office of System Capacity

## December 1997

Prepared jointly by the Federal Aviation Administration, the FAA Technical Center, JIL Information Systems, and Fu Associates.

The purpose of the 1997 Aviation Capacity Enhancement (ACE) Plan, produced by the FAA Office of System Capacity (ASC), is to describe FAA initiatives that will enhance the capacity and performance of the National Airspace System (NAS). The Plan is divided into six chapters and four appendices:

- Chapter 1: The National Airspace System
- Chapter 2: Major Capacity Initiatives — Free Flight and NAS Modernization
- Chapter 3: Airport Development
- Chapter 4: Airspace Development
- Chapter 5: New Operational Procedures
- Chapter 6: Capacity Enhancing Technologies

Chapter 1 presents a broad overview of the current status of the NAS. From 1992 to 1996, the number of aircraft operations in the United States remained stable at about 62 million, while the number of aircraft operations at the top 100 U.S. airports increased from 25.3 to 26.6 million, a 5.1 percent increase. The increase in operations at the top 100 U.S. airports indicates that the busiest U.S. airports are getting busier, which will compound problems of congestion at these key airports unless airport and airspace capacity enhancements are made.

The FAA has established goals and performance measures to address four aspects of system capacity: delay, flexibility, predictability, and access. Delay, the traditional measure of NAS performance, held steady at 7.1 minutes per operation from 1992 to 1995, then increased to 7.5 minutes per operation in 1996. The number of operations delayed 15 minutes or more fell steadily from 1992 to 1995, then increased in 1996. The increase in average delay per operation and number of operations delayed was primarily due to unusually harsh storms that occurred in many areas of the U.S. in 1996. Due to well-focused efforts on the part of the FAA and airport authorities in expanding and enhancing airport facilities at many of the busiest airports in the U.S., delays have fallen while the number of operations at those airports increased. User flexibility is improving as a result of several FAA initiatives, such as the National Route Program (NRP) and reduced vertical and horizontal separation minima in oceanic airspace. Likewise, the FAA is working to improve system predictability through the development of integrated systems for the dissemination of weather data. Finally, FAA initiatives to improve access to its facilities and services include providing for and maintaining accessible public use airports, and enhanced communication procedures between the Department of Defense (DOD), the FAA, and air carriers to increase civilian access to special use airspace (SUA) when it is not in use by the military.

Chapter 2 describes the FAA's two major capacity enhancement initiatives - free flight and NAS modernization. Free flight and NAS modernization are interdependent initiatives which aim to provide the new technologies and procedures that will increase NAS efficiency. The main objective of free flight is to remove restrictions that hinder the efficient flow of traffic while maintaining or improving the current high level of safety. Transitioning to free flight requires both procedural and technological advances. The FAA has already initiated many of the procedural changes required for free flight, and is in the process of modernizing and replacing much of the equipment, computers, and software used to manage air traffic and assure safe operations. Flight 2000 is a demonstration project planned to test and validate free flight capabilities that will be made possible by modernized air traffic equipment and avionics.

Airport capacity enhancements are the subject of Chapter 3, Airport Development. There are approximately 3,300 airports in the U.S. that are considered significant to the capacity of the NAS. Of the top 100 airports, 61 are developing or have recently completed new runways or runway extensions to increase airport capacity. In this chapter, top priority capacity projects from six of the nine FAA regions are described. Since 1985, more than 40 airport capacity design team studies have been conducted. A table in this chapter indicates those recommendations that were implemented, and those that are no longer under consideration. Finally, ongoing airport capacity studies are described.

Chapter 4, Airspace Development, describes ongoing terminal and en route airspace analyses. Airspace development studies focus on restructuring airspace, rerouting traffic, or modifying arrival, departure, en route, or terminal flow patterns to relieve congestion and reduce delays. The FAA is currently involved in a large-scale analysis of the airspace on the west coast of the United States, as well as studies of the airspace around Salt Lake City, UT and Phoenix, AZ.

A cost-efficient alternative to airport and airspace development is modifying air traffic control procedures to improve the flow of aircraft in the en route and terminal area. Chapter 5 describes new and developing air traffic control procedures requiring minimal or no investment in new technology. For example, in the en route environment, the National Route Program is allowing pilots to fly more direct routes. In the oceanic environment, reduced horizontal and vertical separation minima will provide pilots with more flexibility and efficient routing. Additionally, less restrictive instrument approach procedures are being developed for the terminal environment.

Chapter 6, Capacity Enhancing Technologies, is divided into five areas: communications, navigation, surveillance, weather, and air traffic management. For each area, characteristics of the current system are described, followed by a description of planned enhancements and the key technologies that will make those enhancements possible. A table listing all of the currently funded capacity-enhancing technology projects is presented for each area.

Figure 1 summarizes the components of capacity enhancement and reflects the content and organization of the ACE Plan.

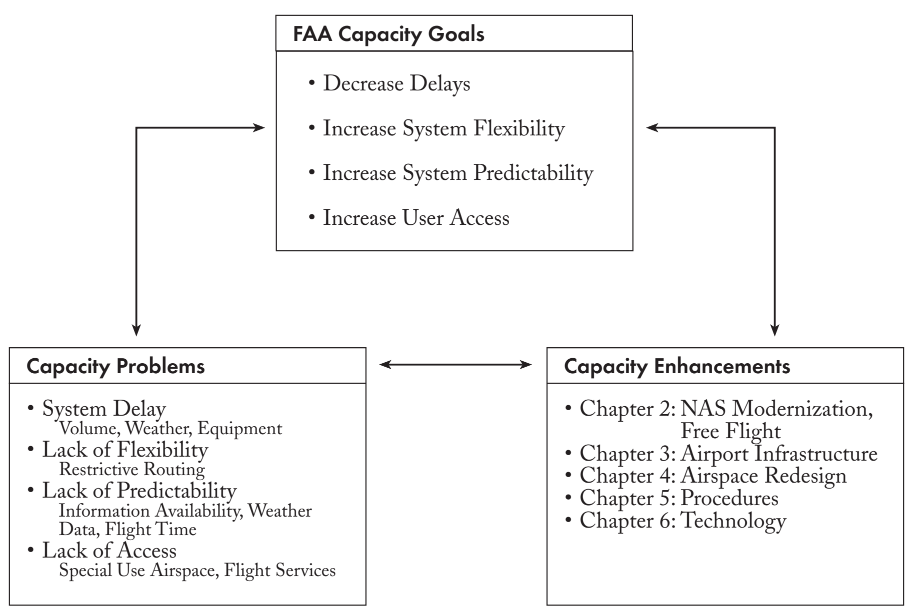


**Figure 1.**

Capacity Enhancement and ACE Plan Organization

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# INTRODUCTION

The purpose of the Aviation Capacity Enhancement (ACE) Plan is to describe FAA initiatives that enhance the capacity and performance of the National Airspace System (NAS). The FAA's commitment to improving system capacity is captured by Goal 4 of the 1996 FAA Strategic Plan:

> *Meet the capacity needs for air and space transportation safely and efficiently through near-term actions targeted at specific problems and a long-term comprehensive program of research, planning, and investment matching user needs.*

The FAA Performance Plan, required by the Government Performance and Results Act (GPRA), supplements the FAA Strategic Plan by setting annual goals with measurable target levels of performance, and addresses specific aspects of capacity such as delay, flexibility, predictability and access. Improving aviation system capacity is a continuing dynamic process that evolves as user needs change and technology advances.

The ACE Plan is produced by the FAA Office of System Capacity (ASC). ASC identifies and evaluates capacity enhancements such as airport expansion, airspace redesign, and new operational procedures to ensure that the capacity of the U.S. Aviation System keeps pace with demand for aviation services. Although ASC is the only office with capacity enhancement as its primary mission, the activities of many offices within the FAA and other agencies such as the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD) play key roles in capacity enhancement. For example, within the FAA, the Office of Research and Acquisitions (ARA) enhances capacity through the development of advanced air traffic control technologies. The Office of Airports (ARP) provides grants and authorizes the collection and use of passenger facility charges (PFC) for funding capacity-enhancing airport development projects. Moreover, Air Traffic Services (ATS), of which ASC is one component, plays a critical role in maintaining and expanding capacity through the installation and maintenance of air traffic control equipment, and keeping air traffic flowing smoothly 24 hours a day, 365 days a year.

The ACE Plan is organized by chapters. *Chapter 1:The National Airspace System* describes changes in levels of aviation activity and FAA capacity goals for four aspects of system capacity — delay, flexibility, predictability and access. *Chapter 2: Major Capacity Initiatives — Free Flight and NAS Modernization* describes these interdependent efforts to improve aviation capacity through the development of new procedures and technologies. *Chapter 3: Airport Development* describes ongoing airport construction projects and airport capacity enhancement studies. *Chapter 4: Airspace Development* describes ongoing airspace analysis projects designed to achieve more efficient en route air traffic patterns in congested airspace. *Chapter 5: New Operational Procedures* describes new en route and terminal approach procedures which increase system capacity. *Chapter 6: Capacity Enhancing Technology* describes technological advances in the areas of communication, navigation, surveillance, weather, and air traffic management, which will improve the quality of aviation services and support implementation of free flight.

The appendices contain useful data on the aviation system. Appendix A provides various aviation activity statistics for the top 100 airports. Appendix B contains diagrams of the top 100 airports, with descriptions of new or planned construction. Appendix C is a list of acronyms, and Appendix D is a survey.

# Chapter 1: The National Airspace System

Assuring that the capacity of the NAS can accommodate the growing demand for aviation services is critical to the Nation's economic future. In 1996, civil aviation provided almost 10.1 million jobs with total earnings of over $282 billion; economic activity generated by aviation during that year amounted to $974 billion. In the next 10 years, the demand for FAA aviation services will expand slowly, but steadily. This increased demand will be placed on an aviation system where key airports and terminal areas are already frequently congested.

This chapter provides information on current and projected aviation activity and on changes in flight delay and other measures of system capacity and performance. Aviation activity data indicate the demand on the system; system performance measures indicate the ability of the aviation system to accommodate the demand.

## Aviation Activity

Aircraft operations, passenger enplanements, air cargo tonnage, and ARTCC traffic volume are all indicators of aviation activity and demand for FAA services. This section describes trends in these indicators.

### U.S. Aircraft Operations and Passenger Enplanements

From 1992 to 1996 the number of aircraft operations in the United States remained stable at approximately 62 million. Over the same period, the number of air carrier and regional/commuter enplanements increased steadily from 506 million to 606 million, a 20 percent increase. By 2008, operations are expected to increase to 72.3 million (a 17 percent increase over 1996), and enplanements to 995 million (a 64 percent increase over 1996). The higher growth predicted for passenger enplanements relative to aircraft operations is primarily the result of higher load factors and larger seating capacity for air carrier aircraft. Figure 1-1 illustrates the trend in aircraft operations and passenger enplanements nationwide and at the top 100 airports in the United States.[1]

1. Based on 1996 passenger enplanements in the FAA's *Terminal Area Forecasts*.

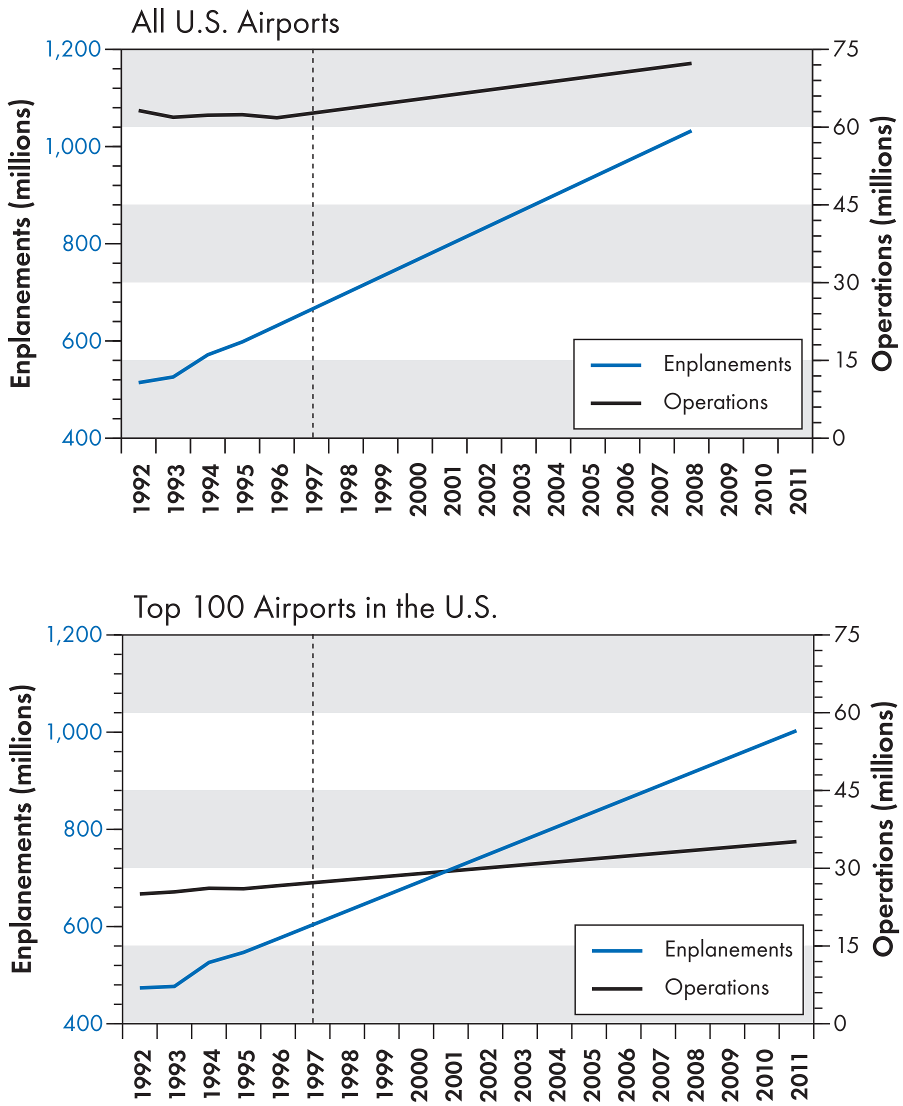


**Figure 1-1.**

Growth in U.S. Passenger Enplanements and Operations

### Aircraft Operations and Passenger Enplanements at the Top 100 Airports

The top 100 airports in the United States, as measured by 1996 passenger enplanements, are shown in Figure 1-2. These 100 airports accounted for almost 95 percent of the 606 million passengers in the U.S. in 1996.

The number of aircraft operations at the top 100 airports increased from 25.3 million in 1992 to 26.6 million in 1996, a 5.1 percent increase. Over the same period, the number of air carrier and regional/commuter enplanements increased from 474 million to 575 million, a 21 percent increase. By 2011, aircraft operations at the top 100 airports are projected to increase to 35.1 million (a 32 percent increase over 1996), and enplanements to 1 billion (a 74 percent increase over 1996). Operations and enplanement data for 1994, 1995, and 1996 and forecasts of operations and enplanements for the top 100 airports in 2011 are included in Appendix A.

## Air Cargo

Air cargo is increasingly important to the economy of the United States. In 1996, air cargo accounted for 23 percent of U.S. imports and 31 percent of U.S. exports by dollar value, up from 18 percent of imports and 28 percent of exports by dollar value in 1990.[2] Air transportation is a preferred mode of shipment for high-value, lightweight, perishable, and time-sensitive goods. Over the next seven years, world air cargo traffic is projected to grow at a faster rate than air passenger traffic.[3]

Air cargo is transported in the baggage compartments of scheduled passenger aircraft and by all-cargo aircraft. In 1990 half of the air cargo tonnage in the U.S. was transported by all-cargo aircraft, and half of the tonnage was transported by passenger aircraft. By 1996, two-thirds of air cargo tonnage was transported by all-cargo aircraft, and only one third by passenger aircraft. Over the same time period, the tonnage carried by all-cargo carriers in the U.S. domestic market more than doubled. The increasing dominance of all-cargo carriers in the domestic market is projected to continue, increasing the number of all-cargo operations and demand for air traffic services at key cargo airports. However, most all-cargo flights are scheduled during off-peak periods and do not substantially contribute to airport congestion and delay problems. Table 1-1 lists the top 25 U.S. airports by cargo tonnage loaded and unloaded.

Air cargo is increasingly important to the economy of the United States. Over the next seven years, world air cargo traffic is projected to grow at a faster rate than air passenger traffic.

2. U.S. Department of Commerce, International Trade Administration
3. Boeing, from MergeGlobal 1997 World Air Freight Industry Analysis and Forecast.

## Table 1-1.

### Top 25 U.S. Airports by Total Cargo, 1996[4]

| City | Airport | ID | Total Cargo* |
|---|---|---|---|
| Memphis, TN | Memphis International | MEM | 1,934 |
| Los Angeles, CA | Los Angeles International | LAX | 1,719 |
| Miami, FL | Miami International | MIA | 1,710 |
| New York, NY | John F. Kennedy International | JFK | 1,636 |
| Louisville, KY | Louisville Standiford Field | SDF | 1,369 |
| Anchorage, AK | Anchorage International | ANC | 1,269 |
| Chicago, IL | O'Hare International | ORD | 1,260 |
| Newark, NJ | Newark International | EWR | 958 |
| Atlanta, GA | Hartsfield Atlanta International | ATL | 800 |
| Dallas/Ft. Worth, TX | Dallas-Ft. Worth International | DFW | 775 |
| Dayton, OH | Dayton International | DAY | 767 |
| San Francisco, CA | San Francisco International | SFO | 712 |
| Oakland, CA | Metropolitan Oakland International | OAK | 615 |
| Indianapolis, IN | Indianapolis International | IND | 609 |
| Philadelphia, PA | Philadelphia International | PHL | 494 |
| Hounolulu, HI | Honolulu International | HNL | 436 |
| Boston, MA | Boston Logan International | BOS | 406 |
| Denver, CO | Denver International | DEN | 390 |
| Seattle-Tacoma, WA | Seattle-Tacoma International | SEA | 388 |
| Minneapolis-St. Paul, MN | Minneapolis-St. Paul International | MSP | 361 |
| Toledo, OH | Toledo Express | TOL | 345 |
| Detroit, MI | Detroit Metropolitan | DTW | 320 |
| Houston, TX | George Bush Intercontinental | IAH | 310 |
| Washington, DC | Washington Dulles International | IAD | 309 |
| Cincinnati, OH | Greater Cincinnati International | CVG | 289 |

* Loaded and unloaded freight and mail in thousands of metric tons.

4. "The World's Airports in 1996: Airport Ranking by Total Cargo." Airports Council International. http://www.airports.org/cargo96.html

### Traffic Volume in Air Route Traffic Control Centers (ARTCCs)

From FY96 to FY97 instrument flight rules (IFR) operations increased at 19 of the 20 Continental United States (CONUS) ARTCCs. The number of aircraft flying under IFR handled by ARTCCs totaled 40.8 million in FY97, an increase of 1.4 percent over FY96.

The five busiest ARTCCs in FY97 were: Chicago, Cleveland, Atlanta, Washington, and Indianapolis. Forecasts for FY08 indicate a change in ranking of the busiest ARTCCs to: Chicago, Cleveland, Washington, Atlanta, and Indianapolis. The ARTCCs with the highest average annual growth rates are Boston and Los Angeles, which are projected to grow by 2.3 and 2.2 percent respectively. Figure 1-3 is a map of the 20 CONUS ARTCCs. Figure 1-4 shows the number of operations by ARTCC for FY96 and FY97, and forecast operations for FY08.

## System Performance Measures

Capacity-enhancing programs such as airport expansion and the development of more efficient air traffic control procedures are targeted at improving NAS performance. The FAA is developing performance goals to address the following four aspects of system capacity:

- Delay: the extent to which flights do not depart or arrive within the planned, expected, or scheduled time;
- Flexibility: the extent to which the air traffic control system allows users to optimize their operations based on their own objectives and constraints;
- Predictability: the variation in the air traffic management system as experienced by the user; and,
- Access: the ability of users to access airports, airspace, and services.

To ensure that capacity-enhancing efforts address these aspects of system performance, the FAA has, in addition to delay, begun to track flexibility, predictability, and access performance measures and establish targets for improvement. The measures will be used to monitor the capacity and performance of the aviation system and evaluate proposed capacity and performance enhancements. These actions are consistent with the Government Performance and Results Act (GPRA) of 1994, which requires all Federal agencies to set performance goals, tie their budget requests to those goals, and measure their success in achieving them. Figure 1-5 illustrates common capacity constraints and FAA goals and strategies for addressing those constraints.

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**Figure 1-2.**

Top 100 Airports Based on 1996 Passenger Enplanements

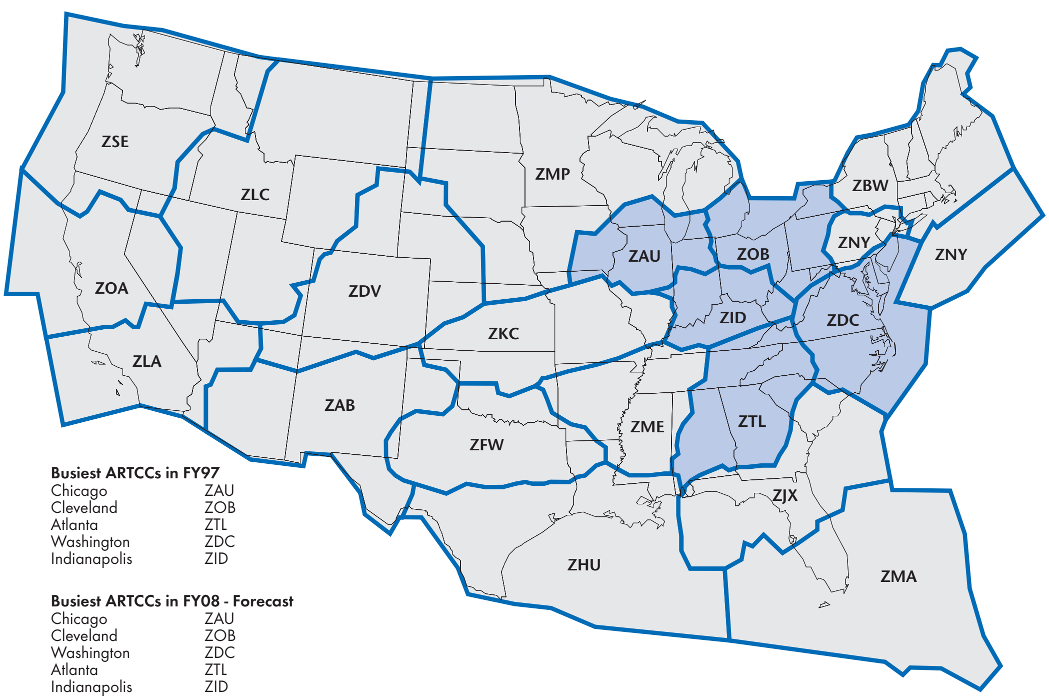



**Figure 1-3.**

CONUS Air Route Traffic Control Centers

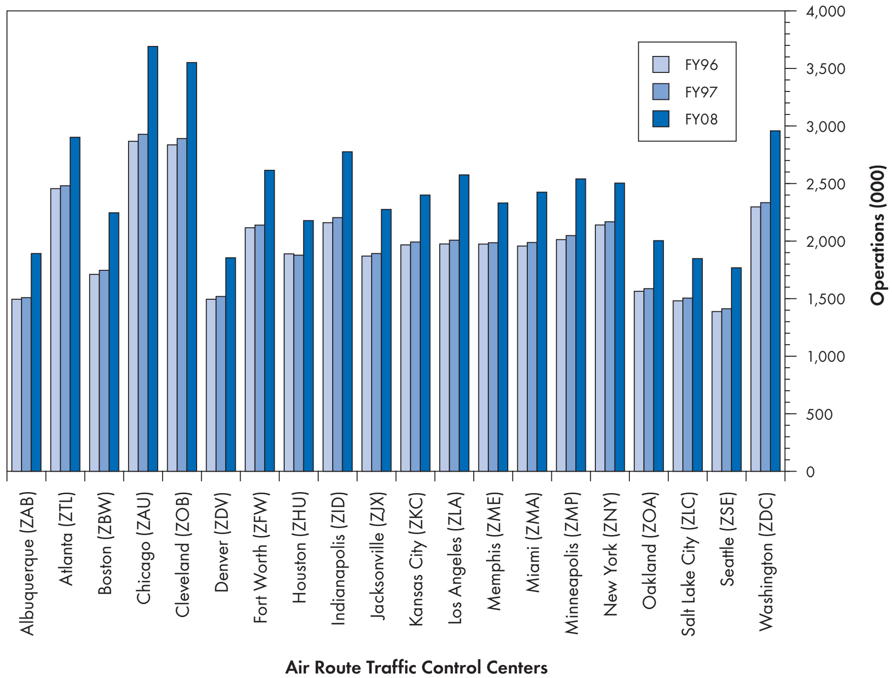



**Figure 1-4.**

Operations at CONUS ARTCCs

| Capacity Constraints | FAA Capacity Goals | Strategies/Enhancements | | | |
|---|---|---|---|---|---|
| **Delay** | **Reduce Delays** | **Chapter 3 Airport Dev.** | **Chapter 4 Airspace Dev.** | **Chapter 5 Procedures** | **Chapter 6 Technology** |
| Air Traffic Volume | • Reduce the rates of volume related delays. | X | X | X | X |
| Equipment | • Reduce the rates of equipment related delays. | | | | X |
| | • Accelerate NAS modernization by reducing the time it takes to acquire and field systems. | | | | X |
| | • Put into operational service 100 percent of the integrated systems necessary to deliver the capabilities required to modernize the NAS, as documented in Version 3.0 of the NAS architecture. | | | | X |
| Weather | • Develop and demonstrate the ability of new systems to decrease the rate of weather-related delays. | | | | X |
| | • Reduce weather-related delays due to restrictive instrument approach procedures. | | | X | |
| Airports | • Increase system capacity attributable to airport infrastructure. | X | | | X |
| **Lack of Flexibility** | **Increase System Flexibility** | | | | |
| Routing | • Reduce the amount of extra flight plan miles associated with ATC-preferred routes. | | | X | |
| | • Increase the percentage of flight segments flown off the ATC-preferred routes. | | | X | |
| **Lack of Predictability** | **Increase Predictability** | | | | |
| Information availability | • Increase the level of information available to system users and involve them more frequently in operational decision making. | | | X | X |
| Weather Data | • Make improvements in obtaining and disseminating. weather products. | | X | X | |
| Flight Time | • Improve in-flight and ground movement predictability. | X | X | | |
| **Lack of Access** | **Increase User Access** | | | | |
| Airspace | • Improve civilian access to special use airspace when not in use by military. | | X | X | |
| Flight Services | • Reduce the average flight service call waiting time. | | | | X |
| Airports | • Increase access to airports during IFR weather conditions. | X | | X | X |

**Figure 1-5.**

Capacity Constraints, Goals, and Strategies

## Delay

The FAA uses two sources of delay data, the Air Traffic Operations Management System (ATOMS) and the Airline Service Quality Performance (ASQP) database. ATOMS, recorded by FAA personnel, is a record of aircraft delayed in excess of 15 minutes by cause (weather, terminal volume, center volume, closed runways or taxiways, and NAS equipment interruptions) during any phase of flight. Aircraft delayed by less than 15 minutes are not included in ATOMS. A delay is recorded if an aircraft is delayed 15 minutes or more during taxi out or 15 minutes or more in any en route center. Thus, an aircraft could be delayed 14 minutes during taxi out and 14 minutes in each ARTCC it passes through and not be recorded as a delay by ATOMS. Taxi-in delays are not counted.

Approximately 272,000 flights in 1996 were delayed 15 or more minutes, an increase of 14.7 percent from 1995.

ASQP data, controlled by DOT, are collected from airlines with one percent or more of the total domestic scheduled service passenger revenue. ASQP records delays as small as one minute by phase of flight (i.e., gate-hold, taxi-out, airborne, or taxi-in delays). ASQP is used primarily for consumer on-time performance reporting.

### Delay by Cause: Weather, Equipment, and Volume

Approximately 272,000 flights in 1996 were delayed 15 or more minutes, an increase of 14.7 percent from 1995. The increase in flight delays is primarily due to adverse weather; unusually harsh storms resulted in the disruption of operations at numerous airports during several months of FY96. As a result, weather was attributed as the primary cause of 75 percent of operations delayed by 15 minutes or more in 1996, up from 72 percent in 1995.

Weather-related delays are largely the result of restrictive instrument approach procedures required in adverse weather to maintain safety. The FAA is developing more efficient IFR approach procedures, such as the missed approach procedure for simultaneous approaches described in Chapter 5. Weather-related delays are also caused by the absence of precision landing aids at certain airports, preventing aircraft from landing at those airports in IMC conditions. The FAA continues to install and upgrade instrument landing systems (ILSs) to support operations during conditions of reduced visibility. Improved technology for detecting adverse weather and disseminating weather data, described in Chapter 6, will also reduce weather-related delays.

Table 1-2 illustrates trends in the distribution of flights delayed 15 minutes or more by primary cause. Air traffic volume in the terminal area accounted for 18 percent of delays of 15 minutes or more in 1996, unchanged from 1995. Delays due to equipment failures fell from 3 percent in 1995 to 2 percent in 1996.

**Table 1-2.**

Distribution of Delay Greater Than 15 Minutes by Cause

| Distribution of Delay Greater than 15 Minutes by Cause | | | | | |
|---|---|---|---|---|---|
| **Cause** | **1992** | **1993** | **1994** | **1995** | **1996** |
| Weather | 65% | 72% | 75% | 72% | 75% |
| Terminal Volume | 27% | 22% | 19% | 18% | 18% |
| Center Volume | 0% | 0% | 0% | 0% | 0% |
| Closed Runways/Taxiways | 3% | 3% | 2% | 3% | 3% |
| NAS Equipment | 2% | 2% | 2% | 3% | 2% |
| Other | 3% | 2% | 2% | 4% | 2% |
| **Total Operations Delayed (000s)** | **281** | **276** | **248** | **237** | **272** |

Delays created by equipment outages will be reduced as components of the National Airspace System (NAS) infrastructure are replaced. Additional strategies to reduce delays include the following:

- Implement improved weather systems to mitigate the impacts of weather: Automatic Surface Observing System (ASOS) and Weather and Radar Processor (WARP). Test the Integrated Terminal Weather System (ITWS) (see Chapter 6).
- Deploy prototype automation tools such as the Center TRACON Automation System's (CTAS) Passive Final Approach Spacing Tool (FAST) (see Chapter 6). Complete implementation of the Display Channel Control Replacement (DCCR) program (see Chapter 6).
- Implement new procedures that take advantage of additional runway and airport capacity increases at various locations (see Chapter 5).
- Field infrastructure replacement programs that will reduce equipment-related delay. Display System Replacement (DSR) and the Standard Terminal Automation Replacement System (STARS) will replace an aging display and computing infrastructure that have caused several high-visibility delays (see Chapter 6).

### Delay by Phase of Flight

Table 1-3 displays the average delay by phase of flight. More delays occur during the taxi-out phase than any other phase. From 1992 to 1995, taxi out delays held steady at around 6.9 minutes per flight, but increased to 7.3 minutes per operation in 1996. Airborne delays averaged 4.4 minutes per aircraft in 1996. To put this in perspective, there were approximately 6.9 million air carrier flights in 1996. With an average airborne delay of 4.4 minutes per aircraft, a total of almost 506,000 hours of airborne delay occurred that year, costing the airlines $809 million at an estimated $1,600[5] per hour. The delay per operation held steady at 7.1 minutes from 1992 to 1995, but increased to 7.5 minutes per operation in 1996. Like the increase in weather-related delays in 1996 displayed in Table 1-2, the increase in delay per operation is primarily due to unusually harsh storms that disrupted operations at numerous airports during several months of 1996.

**Table 1-3.**

Average Delay by Phase of Flight

**Average Delay by Phase of Flight**
(minutes per flight)

| Phase | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|
| Gate-hold | 1.1 | 1.0 | 1.1 | 1.1 | 1.1 |
| Taxi-out | 6.9 | 6.9 | 6.8 | 6.8 | 7.3 |
| Airborne | 4.1 | 4.1 | 4.1 | 4.1 | 4.4 |
| Taxi-in | 2.2 | 2.2 | 2.2 | 2.2 | 2.3 |
| Total | 14.3 | 14.2 | 14.2 | 14.2 | 15.1 |
| Minutes per Operation | 7.1 | 7.1 | 7.1 | 7.1 | 7.5 |

5. The actual average aircraft operating cost is $1,587 per hour. The cost for heavy aircraft 300,000 lbs. or more is $4,575 per hour of delay, large aircraft under 300,000 lbs. and small jets, $1,607 per hour, and single-engine and twin-engine aircraft under 12,500 lbs., $42 and $124 per hour respectively. These figures are based on 1987 dollars.

## Identification of Delay-Problem Airports

From 1992 to 1996, the proportion of air carrier flights delayed 15 minutes or more decreased at 33 of the 55 airports at which the FAA collects air traffic delay statistics. From 1995 to 1996, however, the proportion of flights delayed decreased at only 16 of the 55 airports. Table 1-4 lists the number of operations delayed 15 minutes or more per 1,000 operations from 1992 to 1996 at 51 of these airports. The proportion of flights delayed ranges from nearly 65 per 1,000 operations at Newark International Airport to 0.08 per 1,000 operations at Kahului Airport. Of the nine airports with more than 20 delays of 15 minutes or more per 1,000 operations in 1996, three were in the New York area.

From 1992 to 1996, the proportion of air carrier flights delayed 15 minutes or more decreased at 33 of the 55 airports at which the FAA collects air traffic delay statistics.

Figure 1-6 illustrates trends in operations and delays at ten of the busiest airports in the United States from 1992 to 1996. At ORD, DFW, ATL, and EWR, a smaller proportion of flights were delayed 15 minutes or more in 1996 than in 1992, while the number of operations increased. Delays at EWR, however, remain among the highest in the country. The only construction planned at EWR is a runway extension. At LAX, STL, and MSP, operations and delays were higher in 1996 than they were in 1992. At STL, a planned new runway will increase capacity. Likewise, at MSP a runway extension completed in October 1996, and a new runway in the planning stages, will increase capacity. At LAX, however, no significant airport improvements are expected in the near-term. Delay reductions will depend primarily on the development of more efficient airspace design and management.

## Identification of Airports With More Than 20,000 Hours of Delay

Despite ongoing capacity improvements and reduced delay system-wide, certain airports continue to account for significant delay. In 1996, 26 airports each exceeded 20,000 hours of annual aircraft flight delay. With an average aircraft operating cost of about $1,600 per hour of delay, each of these 26 airports contributed at least $32 million dollars in annual delay costs. Assuming airport capacity is not improved, 31 airports are forecast to exceed 20,000 hours of annual aircraft flight delay each by the year 2006. Table 1-5 lists airports exceeding 20,000 hours of annual delay in 1996 and in 2006, assuming no capacity improvements.

It should be noted that hours of delay are a function of the number of operations and the average delay per operation. An airport with 300,000 operations and an average delay of four minutes per operation has 20,000 hours of delay. As the operations increase, the delay per operation could go down and the airport could still have more than 20,000 hours of delay.

## Table 1-4.

### Delays of 15 Minutes or More Per 1,000 Operations at Selected Airports

| Airport | ID | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|
| Newark International Airport | EWR | 83.48 | 87.88 | 74.29 | 33.81 | 65.25 |
| San Francisco International Airport | SFO | 30.18 | 23.79 | 28.46 | 54.71 | 56.57 |
| New York LaGuardia Airport | LGA | 55.23 | 38.32 | 47.37 | 33.65 | 46.22 |
| Chicago O'Hare International Airport | ORD | 45.40 | 47.49 | 26.83 | 30.93 | 34.46 |
| Lambert St. Louis International Airport | STL | 14.96 | 19.54 | 22.72 | 33.87 | 34.04 |
| New York John F. Kennedy International Airport | JFK | 41.23 | 35.68 | 35.79 | 17.38 | 29.53 |
| Boston Logan International Airport | BOS | 34.61 | 39.23 | 29.79 | 22.15 | 26.37 |
| Los Angeles International Airport | LAX | 19.75 | 9.15 | 10.96 | 27.03 | 24.13 |
| Hartsfield Atlanta International Airport | ATL | 29.90 | 23.28 | 19.98 | 24.26 | 23.88 |
| Dallas-Fort Worth International Airport | DFW | 29.82 | 33.71 | 37.65 | 26.80 | 19.59 |
| Philadelphia International Airport | PHL | 18.47 | 18.75 | 20.85 | 6.89 | 17.95 |
| George Bush Intercontinental Airport | IAH | 7.86 | 8.06 | 5.52 | 10.79 | 11.45 |
| Greater Cincinnati International Airport | CVG | 5.95 | 6.38 | 6.40 | 4.88 | 10.38 |
| Minneapolis-St. Paul International Airport | MSP | 4.36 | 7.16 | 3.52 | 9.23 | 9.29 |
| Detroit Metropolitan Wayne County Airport | DTW | 11.24 | 9.05 | 6.95 | 10.52 | 9.10 |
| Phoenix Sky Harbor International Airport | PHX | 8.16 | 2.86 | 3.48 | 4.97 | 7.25 |
| Washington Dulles International Airport | IAD | 7.33 | 6.86 | 8.43 | 4.54 | 6.81 |
| Miami International Airport | MIA | 9.68 | 10.48 | 10.47 | 11.00 | 6.79 |
| Chicago Midway Airport | MDW | 2.12 | 2.98 | 3.10 | 4.03 | 6.70 |
| Greater Pittsburgh International Airport | PIT | 8.04 | 6.86 | 4.20 | 2.99 | 6.60 |
| Charlotte/Douglas International Airport | CLT | 6.19 | 3.79 | 4.90 | 4.75 | 6.55 |
| Washington National Airport | DCA | 11.03 | 9.34 | 10.44 | 5.61 | 6.53 |
| Seattle-Tacoma International Airport | SEA | 13.19 | 6.78 | 6.09 | 4.77 | 6.37 |
| Cleveland Hopkins International Airport | CLE | 1.58 | 2.37 | 1.62 | 3.74 | 4.68 |
| Orlando International Airport | MCO | 8.95 | 4.72 | 5.37 | 3.61 | 4.59 |
| Tampa International Airport | TPA | 4.29 | 3.88 | 3.22 | 1.62 | 4.43 |
| Las Vegas McCarran International Airport | LAS | 0.31 | 0.46 | 0.78 | 1.62 | 3.68 |
| Baltimore-Washington International Airport | BWI | 5.80 | 3.94 | 5.15 | 2.68 | 3.67 |
| Salt Lake City International Airport | SLC | 5.07 | 3.86 | 2.79 | 3.16 | 3.53 |
| San Diego International Lindberg Field | SAN | 3.03 | 3.91 | 2.51 | 4.41 | 3.31 |
| San Juan Luis Muñoz Marín International Airport | SJU | 0.56 | 0.30 | 0.71 | 5.29 | 2.92 |
| Houston William P. Hobby Airport | HOU | 2.74 | 3.49 | 2.96 | 3.36 | 2.57 |
| Portland International Airport | PDX | 1.78 | 1.94 | 2.41 | 1.47 | 2.41 |
| Denver International Airport* | DEN | 26.26 | 37.92 | 18.14 | 4.01 | 1.90 |
| Raleigh-Durham International Airport | RDU | 3.60 | 1.99 | 1.25 | 0.50 | 1.59 |
| Fort Lauderdale-Hollywood International Airport | FLL | 3.69 | 3.77 | 2.92 | 3.98 | 1.53 |
| San Jose International Airport | SJC | 1.74 | 0.38 | 0.72 | 1.03 | 1.39 |
| Bradley International Airport | BDL | 1.96 | 0.95 | 1.15 | 1.29 | 1.36 |
| Ontario International Airport | ONT | 1.33 | 1.24 | 0.96 | 1.96 | 1.06 |
| San Antonio International Airport | SAT | 0.20 | 0.10 | 0.35 | 0.87 | 0.99 |
| Kansas City International Airport | MCI | 0.75 | 1.26 | 1.82 | 2.22 | 0.98 |
| Memphis International Airport | MEM | 1.10 | 1.03 | 0.79 | 0.86 | 0.88 |
| New Orleans International Airport | MSY | 0.62 | 0.33 | 0.21 | 0.60 | 0.83 |
| Nashville International Airport | BNA | 2.91 | 2.72 | 1.55 | 1.46 | 0.73 |
| Dayton International Airport | DAY | 0.29 | 0.29 | 0.76 | 0.24 | 0.60 |
| Indianapolis International Airport | IND | 2.11 | 0.57 | 0.45 | 0.40 | 0.58 |
| Palm Beach International Airport | PBI | 1.02 | 0.81 | 0.39 | 0.57 | 0.46 |
| Anchorage International Airport | ANC | 0.34 | 0.74 | 0.29 | 0.51 | 0.33 |
| Honolulu International Airport | HNL | 0.13 | 0.19 | 0.08 | 0.17 | 0.19 |
| Albuquerque International Airport | ABQ | 0.69 | 0.27 | 0.21 | 0.09 | 0.14 |
| Kahului Airport | OGG | 0.13 | 0.05 | 0.03 | 0.20 | 0.08 |

* 1992 thru 1994 data is for Denver Stapleton Airport, which closed in 1995.
This accounts for the drastic reduction in delay for the 1995 data.

## Table 1-5.

### Airports Exceeding 20,000 Hours of Annual Delay in 1996 and 2006, Assuming No Additional Capacity Improvements

| Annual Aircraft Delay in Excess of 20,000 Hours | | | |
|---|---|---|---|
| 1996 | | 2006 | |
| Atlanta Hartsfield | ATL | Atlanta Hartsfield | ATL |
| Boston Logan | BOS | Boston Logan | BOS |
| | | Baltimore-Washington | BWI |
| Charlotte/Douglas | CLT | Charlotte/Douglas | CLT |
| Cincinnati | CVG | Cincinnati | CVG |
| | | Cleveland | CLE |
| Washington National | DCA | Washington National | DCA |
| Denver International | DEN | Denver International | DEN |
| Dallas-Ft. Worth | DFW | Dallas-Ft. Worth | DFW |
| Detroit | DTW | Detroit | DTW |
| Newark | EWR | Newark | EWR |
| Honolulu | HNL | Honolulu | HNL |
| Houston Intercont'l | IAH | Houston Intercont'l | IAH |
| New York John F. Kennedy | JFK | New York John F. Kennedy | JFK |
| Las Vegas | LAS | Las Vegas | LAS |
| Los Angeles | LAX | Los Angeles | LAX |
| New York La Guardia | LGA | New York La Guardia | LGA |
| Orlando | MCO | Orlando | MCO |
| | | Chicago Midway | MDW |
| | | Memphis | MEM |
| Miami | MIA | Miami | MIA |
| Minneapolis-Saint Paul | MSP | Minneapolis-Saint Paul | MSP |
| Chicago O'Hare | ORD | Chicago O'Hare | ORD |
| Philadelphia | PHL | Philadelphia | PHL |
| Phoenix | PHX | Phoenix | PHX |
| Pittsburgh | PIT | Pittsburgh | PIT |
| | | San Diego | SAN |
| Seattle-Tacoma | SEA | Seattle-Tacoma | SEA |
| San Francisco | SFO | San Francisco | SFO |
| Salt Lake City | SLC | Salt Lake City | SLC |
| St. Louis | STL | St. Louis | STL |

*Source: FAA Office of Policy and Plans*

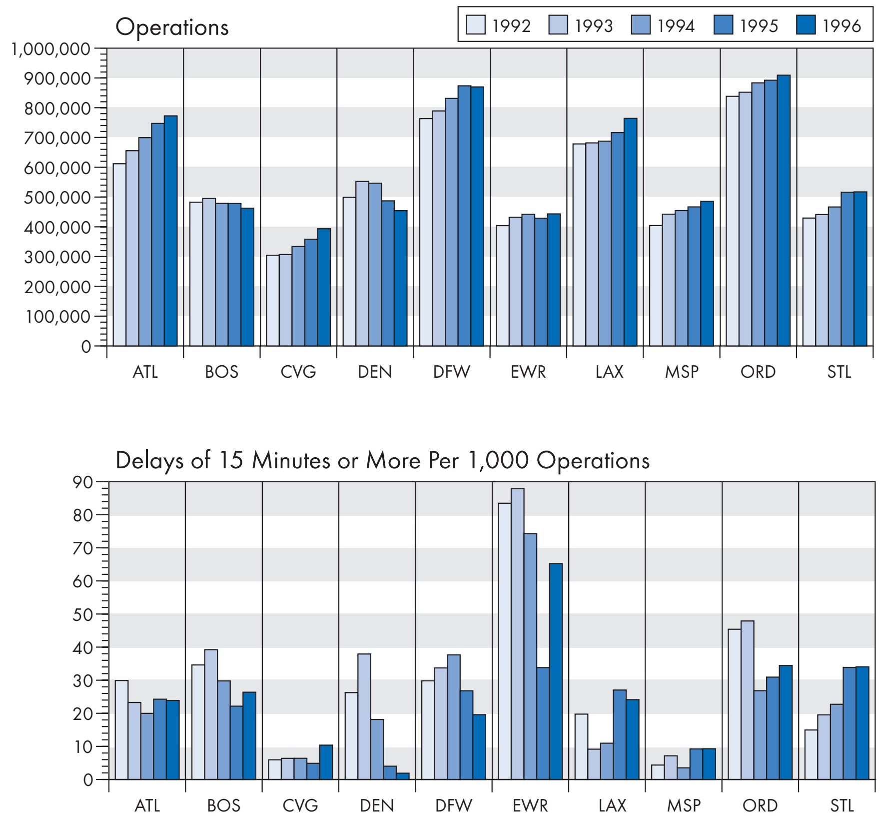



**Figure 1-6.**

**Annual Operations and Delays of Fifteen Minutes or More Per 1,000 Operations at Ten of the Busiest Airports**

## Flexibility

Airlines, general aviation (GA) pilots, and other aviation system users expect more from the air traffic management system than the minimization of delay. They desire the capability to optimize their operations based on their own objectives and constraints, which vary by flight and user. Measuring the flexibility of the air traffic control system allows the FAA to evaluate its ability to permit users to adapt their operations to changing conditions. One measure of flexibility is the proportion of flights that are permitted to operate off ATC-preferred routes.

ATC-preferred routes are important tools that help air traffic controllers organize traffic flows around major airports. On a given day, approximately 30 percent of flights operate between cities with published ATC-preferred routes. Once airborne, approximately 75 percent of the route segments between cities with published ATC-preferred routes are actually flown off of the ATC-preferred routes. This ability to deviate from the ATC-preferred route structure represents a significant portion of the flexibility allowed to users in the air traffic management system.

The following are strategies the FAA is pursuing to increase system flexibility:

- Institute procedural changes to reduce unnecessary ATC-preferred routes (see Chapter 5).
- Implement Flight Management System (FMS) procedures at waypoints for the top 50 airports (see Chapter 5).
- Conduct annual audits of static and dynamic operating restrictions and eliminate unnecessary restrictions (see Chapter 5).
- Implement conflict probe prototypes to identify potential conflicts with more certainty, thereby avoiding unnecessary aircraft maneuvers and improving user flexibility (see Chapter 6).
- Replace the 200 nm constraint of the NRP (National Route Program) with Standard Instrument Departure/Standard Terminal Arrival Routes (SIDS/STAR) as ingress/egress points to the NRP (see Chapter 5).
- Improve flexibility in trans-oceanic flights by implementing Reduced Vertical Separation Minima (RVSM) and Reduced Horizontal Separation Minima (RHSM) (see Chapter 5).
- Relax the 250 knot speed limit below 10,000 feet in Class B airspace (see Chapter 5).

## Predictability

Predictability is defined by the variation in the air traffic management (ATM) system experienced by the user. The majority of system users rely on schedules that determine when aircraft should take-off and land. These schedules are central to the operations of almost all commercial flights, driving crew scheduling, ground service operations, and other operational components. Even the smallest deviation from the planned schedule can cause drastic impacts. One of the most unpredictable portions of a flight is the time the aircraft spends on the ground, prior to takeoff. There are many factors that impact ground movement times, including level of demand, weather, and airport runway configuration.

One of the most unpredictable portions of a flight is the time the aircraft spends on the ground, prior to take-off.

A key strategy for increasing user predictability is improving the quality and quantity of information available to system users and involving them in interactive operational decision making. Additionally, the FAA will improve the technologies available for disseminating weather data, as weather is a significant contributor to the uncertainty in the ATM system. See Chapter 6 for more detailed information on technological enhancements related to weather and predictability (i.e., WARP, ITWS).

## Access

The FAA plans to publish a minimum of 500 GPS approaches a year for the next three years.

Access to the ATM system, airports, airspace, and other FAA services is a basic need of all airspace users. The fundamental point where most users gain access to the ATM system is through airports. The FAA will increase access to the Nation's airports during IFR weather conditions by accelerating the publication of Global Positioning System (GPS) approach procedures to provide more accurate course guidance and increase access to airports in adverse weather conditions. The FAA plans to publish a minimum of 500 GPS approaches a year for the next three years.

An indicator of user access to the ATM system is the timeliness and quality of flight services such as pre-flight briefings on weather conditions, flight plan filing, and en route weather updates. Flight services are provided primarily by Flight Service Stations (FSS) (automated and non-automated) and Direct User Access Terminal Service (DUATS). In addition, pilots can obtain weather briefings through the Telephone Information Briefing System (TIBS) or private weather briefing vendors. Although the number of flight services provided by FSSs is expected to decrease from 1996 levels, the number of DUATS services is expected to increase (see Figure 1-7).

During adverse weather conditions when flight service information is most critical, users are often required to hold until a specialist is available. From 1994 to 1996 the average call waiting time fell from 34 to 30 seconds. To further improve timely access to important flight information, the FAA will begin rerouting calls from busy automated FSSs to facilities with shorter waiting times.

Another critical access issue is the utilization of special use airspace (SUA) by civilian aircraft. The FAA has been working closely with the Department of Defense to improve civilian access to SUA when the military is not utilizing the airspace for its critical mission. The FAA has begun operational trials of improved notification procedures and information transfer with respect to selected sections of SUA (see Chapter 5).

Additional FAA strategies to increase user access include the following:

- Supplement GPS navigation through independent operational testing and evaluation of the Wide Area Augmentation System (WAAS) (see Chapter 6).
- Implement the Operational and Supportability Implementation System (OASIS) to provide improved flight services (see Chapter 6).

The FAA also strives to increase user access by consistently improving airport infrastructure at the busiest airports, maintaining runway pavement in a satisfactory condition, and providing for and maintaining accessible public use airports.

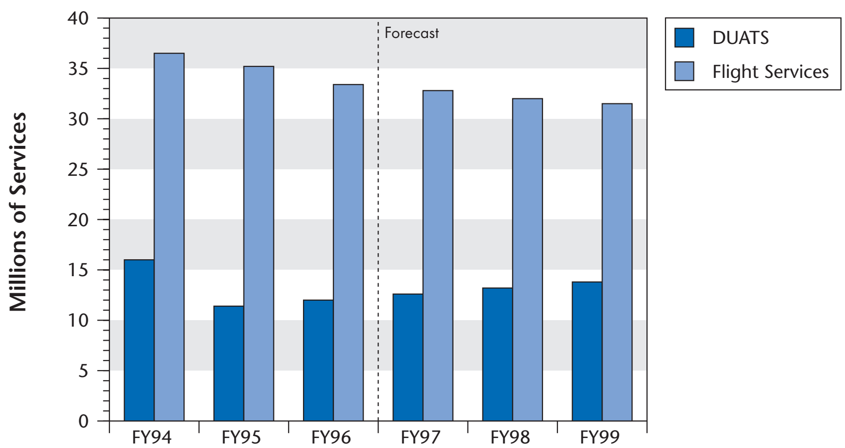



**Figure 1-7.**

Flight Service Activities

CHAPTER 2:
MAJOR CAPACITY INITIATIVES

## Free Flight and NAS Modernization

The capacity of today's National Airspace System (NAS) is constrained by rules, procedures, and technologies that require pilots and air traffic controllers to conduct operations within narrow, often inefficient, guidelines. As air traffic continues to grow, these inefficiencies and their associated costs are compounded. Responding to these limitations, the FAA and the aviation industry are working together on two major interdependent capacity initiatives — free flight and NAS modernization. Flight 2000 is a demonstration project planned to test and validate the free flight capabilities made possible by modernized air traffic equipment and avionics. Implementation of Flight 2000 is dependent on available funding and the NAS modernization schedule.

## Free Flight

Free flight is "a concept for safe and efficient flight operating capability under instrument flight rules (IFR) in which the operators have the freedom to select their path and speed in real time. Air traffic restrictions are imposed only to ensure separation, to preclude exceeding airport capacity, to prevent unauthorized flight through special use airspace (SUA), and to ensure the safety of flight. Restrictions are limited in extent and duration to correct the identified problem. Any activity which removes restrictions represents a move towards free flight."[1] The transition to free flight requires changes in philosophies, procedures, and technologies.

The principal philosophical change required for free flight is a shift from the concept of air traffic control (ATC) to air traffic management (ATM). ATM differs from ATC in several ways: the increased extent of collaboration between users and air traffic managers, greater flexibility for users to make decisions to meet their unique operational goals, and the replacement of broad restrictions with user-determined limits and targeted restrictions only when required.

The procedural changes required for free flight correspond directly to the change in philosophy from ATC to ATM. Under the current air traffic system, aircraft are frequently restricted to ATC-preferred routes, which may not be the routes preferred by the pilot or airline. Air traffic controllers direct pilots to change their direction, speed, or altitude to avoid adverse weather or traffic congestion. In contrast, free flight will grant pilots substantial

1. Final Report of RTCA Task Force 3, Free Flight Implementation, October 26, 1995.

discretion in determining their routes. Many decisions will be collaborative, taking advantage of the best information available to the pilot and air traffic manager to ensure safe, efficient flights.

The principal philosophical change required for free flight is a shift from the concept of air traffic control (ATC) to air traffic management (ATM).

The Radio Technical Commission for Aeronautics (RTCA) Task Force 3, a joint government/industry workgroup leading the free flight planning effort, identified 46 recommendations to promote free flight implementation. Some recommendations require extensive technological changes, such as the development of automatic dependent surveillance-broadcast (ADS-B) to improve surveillance coverage and accuracy. Technological changes required for free flight are described below under NAS Modernization, and more extensively in Chapter 6. Other recommendations involve primarily procedural modifications:

- Remove restrictions to allow for more direct routing;
- Increase civilian access to special use airspace when not in use by the military;
- Implement collaborative traffic flow management procedures and supporting mechanisms;
- Develop missed approach procedures for simultaneous approaches;
- Implement reduced vertical and horizontal separation minima;
- Remove the 250 knot speed limit below 10,000 feet in Class B airspace; and
- Transfer separation responsibility to aircraft on a case-by-case basis.

Several of these initiatives are currently being implemented, and are described in more detail in Chapter 5.

Modernization of the NAS will give users and service providers new abilities such as flexible departure and arrival routes and increased usage of preferred flight trajectories.

## NAS Modernization

To achieve the free flight concept, the FAA is modernizing and replacing much of the equipment, computers, and software used to manage air traffic and assure safe operations. Modernization of the NAS will give users and service providers new abilities such as flexible departure and arrival routes and increased usage of preferred flight trajectories. Ultimately, NAS modernization will increase the flexibility, efficiency, and capacity of the NAS, improve traffic flow and weather predictability, and reduce user operating costs. The schedule and interdependencies of the many technological advances required for NAS modernization and free flight are outlined in the NAS Architecture.

The White House Commission on Aviation Safety and Security recommended the full implementation of NAS modernization by the year 2005. Achieving full modernization by 2005 will pose high-risk cost and performance challenges for the FAA and the airline industry due to technological uncertainties and aggressive scheduling. The FAA expects, however, that the Flight 2000 program (described in this chapter) will mitigate many risks of accelerated modernization through early, integrated research and testing of new technologies and procedures.

The principal NAS modernization changes affecting capacity are categorized into five functional areas: communications, navigation, surveillance, weather, and Air Traffic Management. The transition between the current and future NAS, and the new capabilities created by this change, are described below. The specific technologies within the five areas are described in Chapter 6.

## Communications

In the future, communication between aircraft and ground facilities will require less radio voice communication and a greater use of electronic data transmitted to and from the flight deck via data link technology. Analog radios will be replaced by digital equipment for both voice and data. See Figure 2-1.

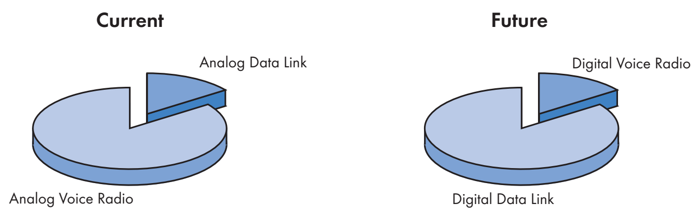



**Figure 2-1.**

Characteristics of Current and Future Communications Systems

Changes in the communication system will create the following capabilities:

- Integration of voice and data communications;
- More efficient use of the frequency spectrum;
- Improved quality and clarity of ATC messages to aircraft;
- Better flight and traffic information services (e.g., weather graphics, proximity traffic data);
- Seamless communications across all operational domains (airport, terminal, enroute, and oceanic);
- Information sharing with all NAS users; and
- An effective interchange network to support dynamic airspace usage.

## Navigation

Navigation will become increasingly reliant on the satellite-based Global Positioning System (GPS) as represented by Figure 2-2. Existing ground-based stations will be decommissioned as new ground-based systems designed to augment the accuracy of GPS are deployed.

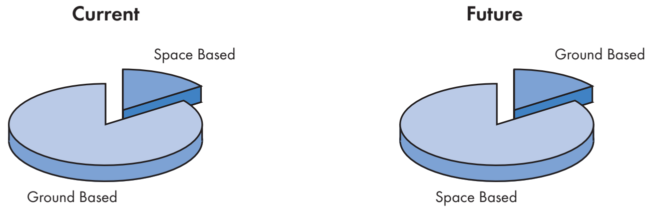



**Figure 2-2.**

Characteristics of Current and Future Navigation Systems

Augmented GPS will create the following capabilities:

- The movement toward user-preferred routing;
- Increased access to airports under IMC through more precision approaches; and
- Decommissioning of costly ground-based navigation and landing systems.

## Surveillance

In the future, surveillance coverage and accuracy will be improved by replacing manually announced aircraft position reports with an onboard navigation system known as Automatic Dependent Surveillance (ADS). ADS automatically and continuously transmits position information that will be combined with radar images to ensure the system's accuracy. Analog radar will be replaced by digital radar as shown in Figure 2-3 below.

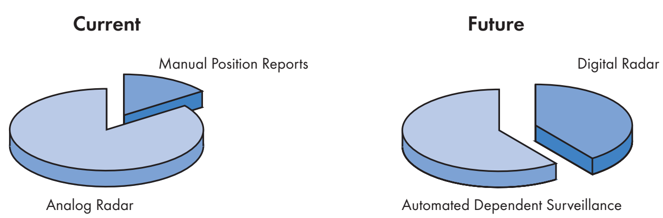



**Figure 2-3.**

Characteristics of Current and Future Surveillance Systems

The implementation of ADS and digital radar will create the following capabilities:

- Continuous surveillance of all positively controlled aircraft;
- More precise monitoring of aircraft separation and flight progression in oceanic airspace;
- Enhanced airport surface surveillance; and
- Reduced separation standards.

## Weather

Today's fragmented weather gathering, analysis, and distribution systems will be enhanced by a more harmonized, integrated system as represented by Figure 2-4. Incremental improvements in weather detection sensors, processors, dissemination systems, and displays will also occur.

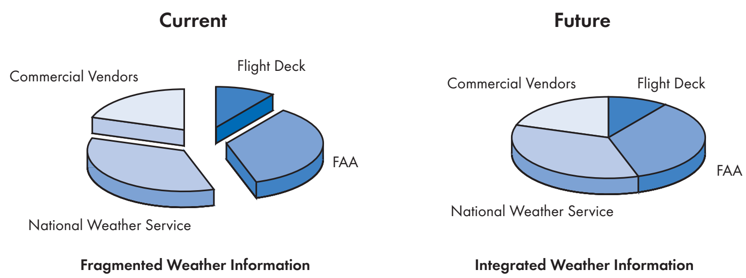



**Figure 2-4.**

Characteristics of Current and Future Weather Systems

Improved weather technologies will allow the following advancements:

- Common situational awareness among service providers and users through the use of integrated weather products;
- NAS-wide availability of distributed weather forecast data;
- Increased accuracy, display, and timeliness of weather information to service providers and users;
- Improved separation of aircraft from convective weather; and
- Integrated weather information into associated air traffic automation systems.

## Air Traffic Management

Manual air traffic control procedures will be replaced by computer-based decision support systems (see Figure 2-5). These systems will improve the efficiency and effectiveness of NAS-wide information, thereby enhancing all phases of surface and flight operations.

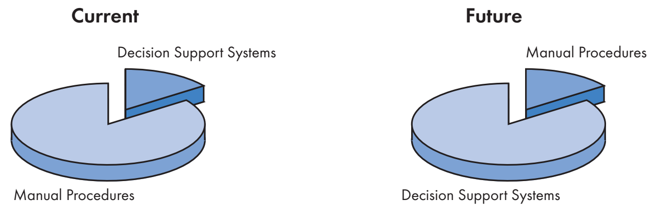



**Figure 2-5.**

Characteristics of Current and Future Air Traffic Management Systems

The use of advanced automation and decision support systems will enable the following:

- Greater collaboration of dynamic airspace management on problem resolution;
- Coordination among local, national, and international traffic flow managers;
- Increased use of airports by assisting in arrival sequencing and spacing, merging streams of traffic, and assigning aircraft to runways;
- Enhanced monitoring, strategy development, and NAS performance measurement;
- International harmonization of data;
- Improved acquisition and distribution of flight-specific data;
- Information updates for static and dynamic data (e.g., route structures, NAS infrastructure status, special use airspace restrictions, aircraft positions/trajectories);
- Improved accommodation of user preferences through improved traffic flow management, conflict detection/resolution, sequencing, and optimal trajectories;
- More flexible airspace structure by reducing boundary restrictions and creating dynamic sectors; and
- Automated information exchange between aircraft and decision support systems.

## Flight 2000

The Flight 2000 initiative will demonstrate and validate a limited set of the capabilities planned for the free flight environment using the key technologies outlined in the NAS Architecture Version 3.0. The objectives of this initiative are to:

- Demonstrate safety and efficiency benefits of new technologies and improved procedures.
- Evaluate communication, navigation, and surveillance (CNS) transition issues.
- Streamline avionics development, certification, and installation, thereby driving down costs.
- Reduce risks for accelerated NAS modernization.
- Develop controller and pilot tools for transition to a free flight environment.

The technical and operational tests will occur in Alaska and Hawaii and the oceanic airspace between the U.S. West Coast and Hawaii. Approximately 2,000 aircraft participating in Flight 2000 will be equipped with a new generation of advanced avionics that include GPS, ADS-B, data link, and cockpit display of traffic information. ATC facilities will be modernized with corresponding ground infrastructure necessary to support digital data link as well as advanced decision support systems (DSS), such as the oceanic conflict probe.

Validation flights in domestic and oceanic airspace will demonstrate the interoperability of these advanced technologies, DSS, and new procedures. On the airport surface, tests will be conducted to determine the effectiveness of systems to detect and communicate the movement of traffic. GPS routes, precision approach, and missed approach procedures will be developed, tested and published. During domestic flight operations, new procedures will be tested to determine when separation between participating aircraft can be safely reduced from current standards using enhanced surveillance provided via ADS-B position reports.

Aircraft flying oceanic routes will test the effectiveness of integrated ADS/GPS/DSS/data link systems to enhance air traffic control and monitoring and improve flexibility and access. Satellite data link will be evaluated as a prime means of ATC communication. New oceanic separation assurance procedures will be validated to determine when separation between participating aircraft can be safely reduced.

Certification is a prime component of Flight 2000 and the successful evolution to a modernized NAS. Certification activities for Flight 2000 will ensure that enabling technologies and associated operational procedures will continue to meet the FAA safety requirements, while reducing time and cost of approval.

The Flight 2000 initiative will demonstrate and validate a limited set of the capabilities planned for the free flight environment using the key technologies outlined in the NAS Architecture.

# CHAPTER 3: AIRPORT DEVELOPMENT

Airports are visible symbols of the economic well-being of the United States. To meet the capacity demands generated by a prosperous economy, it is essential to expand the Nation's airport infrastructure. In this chapter, the expansion and improvement of airports to increase aviation capacity are discussed.

## Airport Capacity in the United States

There are approximately 3,300 airports[1] in the United States that are considered significant to the capacity of the NAS (see Table 3-1). These airports, by inclusion in the National Plan of Integrated Airport Systems (NPIAS), become eligible to receive grants under the Federal Airport Improvement Program (AIP). There are an additional 15,000 small or privately owned landing areas in the United States that are not eligible for AIP grants

Of the 3,300 significant U.S. airports, 411 are considered primary airports[2]. These airports account for 99.9 percent of all commercial enplanements. Delay problems are most prevalent at large-hub primary airports.

## Financing of Airport Capacity Enhancements

Airport capacity enhancements funded by the FAA fall into three general categories: airfield improvements, facilities and equipment, and operational improvements.

### Airfield Improvements

AIP grants are a significant funding source for airfield improvements. AIP grants are intended primarily to: stimulate capacity-enhancement projects such as the construction of runways, taxiways, and aprons; promote safety and security; help finance small and general aviation airports; and pay a significant part of noise and environmental mitigation cost. Between 1985 and 1995, AIP grants financed 14 percent of all capital spending at large commercial airports, 28 percent at medium-sized commercial airports, and 41 percent at small airports (small commercial airports as well as reliever and general aviation facilities).[3] In FY96, the FAA awarded more than $1.5 billion in AIP grants. Airport

1. **Airports** include landing areas developed specifically for helicopters and seaplanes as well as conventional fixed wing aircraft landing areas.
2. **Primary airports** are commercial service airports with more than 10,000 annual passenger enplanements.
3. http://www.faa.gov/ARP/app500/finalcom/eshome.htm

## Table 3-1.

### Distribution of Aviation Activity at U.S. Airports

| Distribution of Aviation Activity at U.S. Airports | | | |
|---|---|---|---|
| Number of Airports | Airport Types | % of Commercial Enplanements | % of Aircraft |
| AIP Eligible Airports | | | |
| 411 | Primary Commercial Service | 99.9% | 20.8% |
| *29* | *Large Hub* | *67.2%* | *1.3%* |
| *42* | *Medium Hub* | *22.2%* | *3.8%* |
| *67* | *Small Hub* | *7.1%* | *4.5%* |
| *273* | *Non Hub* | *3.4%* | *11.2%* |
| 155 | Other Commercial Service | 0.1% | 3.2% |
| 320 | Reliever | 0.0% | 30.0% |
| 2,444 | General Aviation | 0.0% | 37.5% |
| **3,330** | **Total** | **100.0%** | **91.5 %** |
| Non-AIP Eligible Airports | | | |
| 14,961 | Low Activity Landing Areas | 0.0% | 8.5% |

**Primary airports** are commercial service airports with more than 10,000 annual passenger enplanements.

**Commercial Service Airports** are defined as public airports receiving scheduled passenger service and having 2,500 or more enplaned passengers per year.

**Hub** is used by the FAA to identify very busy commercial service airports. For instance:

**Large hubs** are airports that account for more than one percent of passenger enplanements. Some large hub airports have very little passenger transfer activity (LaGuardia, Washington National, and San Diego International-Lingbergh Field, for example) while transfers account for more than half of the traffic at others (Atlanta, Pittsburgh, and St. Louis, for example). General aviation plays a relatively small role at most large hubs.

**Medium hubs** are airports that account for 0.25 percent to 1 percent of passenger enplanements. Medium hub airports have sufficient capacity to accommodate air carrier operations and a substantial amount of general aviation.

**Small hubs** are airports that account for 0.05 percent to 0.25 percent of passenger enplanements. These airports can have a great deal of general aviation activity, with an average of 135 based aircraft (locally owned-aircraft hangared or based at the airport).

**Non-hub primary airports** are commercial service airports that account for less than 0.05 percent of commercial passenger enplanements but more than 10,000 annually. These airports are heavily used by general aviation.

**Other Commercial Service Airports** enplane 2,500 to 10,000 passengers annually. These airports are used mainly by general aviation.

**Reliever Airports** are high-capacity general aviation airports designed to improve GA access to airports in major metropolitan areas.

GA **Airports** are airports that do not receive scheduled commercial service, have at least ten based aircraft, and are at least 30 minutes from the nearest NPIAS airport. The number of based aircraft criterion may be realized for remote locations or other mitigating circumstances. GA airports are generally distributed on a one-per-county basis in rural areas. GA airports are the most convenient source of air transportation for about 19 percent of the population and are particularly important to rural areas.

development is also funded through a combination of Passenger Facility Charges (PFCs), airport revenue and reserves, municipal bonds, commercial loans, and state and local grants.

Public agencies controlling commercial service airports, after receiving approval from the FAA, can charge enplaning passengers a $1, $2, or $3 facility charge. PFC revenues are used primarily for terminal development; they are also used for airport planning, runway, taxiway and apron infrastructure, and airport access. The PFC program currently generates approximately $1 billion annually for airport development. PFC revenues are concentrated at high activity airports. Ten airports generate almost 50 percent of total PFC revenue. Seven of the ten busiest airports are currently collecting PFCs. Thus, PFC revenues are concentrated at airports with the greatest capacity development and noise mitigation needs.

## Facilities and Equipment

Full realization of the capacity benefits of new and extended runways and other airport improvements frequently requires the installation of equipment such as Instrument Landing Systems (ILS), Runway Visual Ranges (RVR), VHF Omnidirectional Ranges (VOR), approach lighting, and Precision Runway Monitors (PRM). This equipment is funded by the FAA's Facilities and Equipment (F&E) budget. Due to funding limitations, installation of equipment must be staggered to give priority to the needs of the most capacity-constrained airports.

## Operational Improvements

Operational improvements to expand airport capacity, such as improved IFR approach procedures and reduced separation standards for arrivals, are primarily funded by the FAA's Research, Engineering, and Development (R,E&D) budget. See Chapter 5 for information on several operational improvements under development.

## Airport Construction and Expansion

Airport development frequently entails the construction of new terminals, new and extended runways, and improved taxiway systems. In large metropolitan areas with frequent flight delays and limited airport expansion possibilities, other options must be explored. New airports, expanded use of existing commercial-service airports, civilian development of former military bases, and joint civilian and military use of existing military facilities are some of the additional options available for meeting expanding aviation needs.

### Conversion of Military Airfields to Civilian Airport Facilities

To date, 20 military airfields have been converted to civil use airports under the DOD Base Realignment Closure program (BRAC). This has resulted in the addition of sixteen runways of lengths ranging from 8,000 feet to 12,000 feet and the replacement of two runways in the civil inventory. Eleven BRAC airports have participated in the Military Airport Program (MAP). The MAP, funded by an AIP set-aside, provides grants to current or former military airports with the potential to improve the capacity of the NAS. Airports remain eligible to participate in the MAP for five fiscal years following their initial designation as participants. There were twelve MAP participants in 1997, six reliever airports, five primary commercial service airports, and one other commercial service airport. Several MAP projects are described below.

In Austin, Texas, the conversion of Bergstrom Air Force Base will replace Robert Mueller Airport, which can no longer meet growing demand. The new airport opened for cargo service in June 1997 and will open for passenger service by May 1999.

The former Williams Air Force Base has been converted to a civil use reliever airport for Phoenix Sky Harbor International Airport. The airport was renamed Williams Gateway Airport. It will serve most categories of civil aircraft with its three runways ranging from 9,300 to 10,400 feet long. The additional airport will add over 290,000 potential annual aircraft operations to the Phoenix airport system.

The former Memphis Naval Air Station has been converted to a civil use reliever airport for Memphis International Airport. The airport was renamed Millington Municipal Airport. It will serve most categories of aircraft with its runway of 8,000 feet. The airport has a potential capacity of 205,000 annual operations.

Other MAP participants include: San Bernardino International Airport, California (a reliever for Los Angeles and Ontario) and Dade County-Homestead Regional, Florida (a reliever for Miami Airport).

## Airport Enhancements for New Large Aircraft (NLA)

New Large Aircraft (NLA) offer the potential of meeting the expected increase in passenger volume in the foreseeable future. With seating capacities expected to be in the 600-800 passenger range and added cargo capacity, NLA may allow airports to provide increased service without major infrastructure alterations. In response to announced plans to build NLA by the year 2003, FAA has formed a NLA Facilitation Group, which will draw on internal and external expertise in airports, air traffic control, aircraft rescue and fire fighting, manufacturing, operations, security, and other relevant areas. This group will address the criteria and conditions under which NLA will operate in the United States.

To make use of existing airport runways, taxiways, ramp, and parking areas with minimal modifications, the maximum fuselage length and wingspan of the NLA must be limited to 80 meters, a figure which some NLA proposals already exceed. Other issues which need to be addressed include the turning radius, the effects of the landing gear on pavement, and the effects of engine thrust on other operations in the airport environment.

The operation of NLA may affect departure and landing separation, as well as ground handling procedures. Such issues as wake vortices and obstacle clearance must be reviewed and special handling procedures may need to be developed. These could include mandatory taxi routes, remote holding or remote gates during infrequent CAT II/III operations, and special accommodations for terminal use.

## Construction of New Airports

The largest NAS capacity gains result from the construction of new airports. However, given the high cost of airport construction (e.g., more than $4 billion for the new Denver International Airport, which opened in 1995), building a new airport is not a common capacity enhancement technique. Currently, no new airports with the potential to significantly impact NAS capacity are being constructed, with the exception of construction required to convert Bergstrom Air Force Base into a civilian airport (see Conversion of Military Airfields above).

The largest NAS capacity gains result from the construction of new airports. However, given the high cost of airport construction, building a new airport is not a common capacity enhancement technique.

## Construction of New Runways and Runway Extensions

The construction of new runways and extension of existing runways is the most direct and significant action to improve capacity at existing airports. Large capacity increases, under both visual flight rules (VFR) and instrument flight rules (IFR), result from the addition of new runways that are properly placed to allow additional independent arrival/departure streams.

Of the top 100 airports, 61 are developing or have recently completed new runways or runway extensions to increase airport capacity.

Of the top 100 airports (based on 1996 passenger enplanements), two completed runway construction projects in 1997. Memphis (MEM), the most significant gateway for U.S. international cargo, completed a new parallel runway, and Boise (BOI) completed a runway extension. Ten additional airports are presently constructing new runways or runway extensions. Of the top 100 airports, 61 are developing or have recently completed new runways or runway extensions to increase airport capacity. Table 3-2 lists new runways and runway extensions that were completed in 1997, are under construction, or are planned or proposed at the top 100 airports.

Of the 26 airports exceeding 20,000 hours of air carrier flight delay in 1996 (see Table 1-5), 17 are planning or constructing new runways or runway extensions. Twenty-one of the 31 airports forecast to exceed 20,000 hours of annual air carrier delay in 2006 are planning or constructing new runways or runway extensions.

## Regional Top Priority Capacity Projects

Six of the nine FAA regions identified the following capacity enhancement projects (planned or underway) as their most important airport development project. Several of these initiatives are the result of recommendations from Airport Capacity Studies, conducted by FAA's Office of System Capacity.

### Western Pacific Region

In accordance with the Phoenix Capacity Enhancement Plan completed in September 1989, a third runway is being constructed at the Phoenix Sky Harbor International Airport (PHX) with a target completion date of September 1999. The relocation of facilities that lie in the new runway's path is one of the most challenging aspects of this project. Replacement facilities for an Arizona Air National Guard complex are being constructed southwest of their current location. The existing airport surveillance radar must also be moved to accommodate runway construction. Upon completion, the third runway will help accommodate the increased airport operations and aviation needs forecast in the PHX Capacity Plan. This runway will prevent additional delays, increased aircraft operating costs and passenger travel times, and will provide the capability to perform simultaneous instrument operations.

### Great Lakes Region

The Milwaukee General Mitchell International Airport plans a 700 foot long extension to runway 7L-25R. This capacity project, while a relatively minor alteration, will postpone the need for a third parallel runway until the year 2015. The $1.9 million project, scheduled for construction in 1998, will decrease commuter aircraft delays by 40 percent, thus yielding significant capacity benefits with a minimal investment.

### Northwest Mountain Region

The Port of Seattle is planning major expansion for the Seattle-Tacoma International Airport (Sea-Tac), including a north unit terminal and a 8,500 foot long third parallel runway 2,500 feet west of Runway 16R/34L. The third parallel runway, to be completed by 2004, will improve the airfield capacity in adverse weather. Adverse weather currently restricts Sea-Tac operations to a single arrival stream 44 percent of the year. The additional runway would allow parallel dependent approaches 99 percent of the year. The total Airport Capital Improvement Program funding through FY2007 is $1.4 billion. The Airport Layout Plan was approved by the FAA on July 7, 1997, and the Port of Seattle has begun acquiring property needed for the planned construction.

### Central Region

The new runway at Lambert-St. Louis is the Central Region's top priority capacity enhancement project. This project, being nearly ten years in the planning phase, has the potential to significantly reduce projected delays both at St. Louis and across the NAS. The estimated cost of the new runway is $850 million with the total expansion effort estimated to cost over $2 billion. The new runway will provide Lambert with the capability to conduct simultaneous independent IFR arrivals. The FAA Technical Center completed a performance analysis on the proposed expansion of Lambert and concluded that the expansion has the potential for system-wide savings of $5.1 billion in operational delay and $9.5 billion in passenger delay over the years 2005-2015. This represents approximately a 14 percent reduction in operational delay and an 18 percent reduction in passenger delays.

### Southern Region

The Hartsfield Atlanta International Airport (ATL) Capacity Design Team recommended a commuter/GA runway complex in its March 1987 Airport Capacity Enhancement Plan. This concept was later modified to a 6,000-foot long fifth parallel commuter

**Table 3-2.**

New and Extended Runways – Completed in 1997, Under Construction, Planned, or Proposed

| Airport | Runway | Est Cost ($M) | Operational Date | Completed in 97 | Under Construction |
|---|---|---|---|---|---|
| Albany (ALB) | 10/28 extension | 5.8 | 2000 | | |
| | 1R/19L parallel | 7.5 | 2010 | | |
| Atlanta (ATL) | 5th E/W parallel | 420.0 | 2002 | | |
| Baltimore (BWI) | 10R/28L parallel | n/a | 2003 | | |
| Bergstrom (new Austin) | 17L/35R parallel | 46.0 | 1998 | | |
| | west runway renovation | 10.0 | 1996 | | X |
| Boise(BOI) | 10L/28R extension | 8.0 | 1997 | X | |
| | 10R/28L Parallel | n/a | 2010 | | |
| Boston (BOS) | 14/32 | n/a | n/a | | |
| Charlotte (CLT) | 18W/36W 3rd parallel | 160.0 | 2001 | | |
| Chicago Midway (MDW) | 4R/22L reconstruction | 32.0 | 1997 | | X |
| Cleveland-Hopkins (CLE) | 5R/23L replacement | 180.0 | 2000 | | |
| | 5L/23R extension | 40.0 | 2005 | | |
| Port Columbus (CMH) | 10L extension | 7.9 | 1997 | | X |
| Dallas-Fort Worth (DFW) | 18L/36R extension | 25.0 | 2002 | | |
| | 18R/36L extension | 25.0 | 2002 | | |
| | 18R/36L new parallel | 268.0 | 2003 | | |
| | 17C/35C extension | 15.0 | 2000 | | |
| Denver Intl (DEN) | 16R/34L parallel | 75.0 | 2000 | | |
| Des Moines (DSM) | 05 extension | 21.5 | 2001 | | X |
| Detroit (DTW) | 4/22 parallel | 116.5 | 2001 | | |
| El Paso (ELP) | 8L/26R parallel | 30.0 | 2010+ | | |
| | 22 extension | 8.0 | 2000 | | |
| Fort Lauderdale (FLL) | 9R/27L extension | 300.0 | 2003 | | |
| Fort Myers (RSW) | 6R/24L parallel | 80.0 | 2002 | | |
| Grand Rapids (GRR) | 18/36 extension | 58.0 | 1997 | | X |
| Greensboro (GSO) | 5L/23R parallel | n/a | 2020 | | |
| | 14/32 extension | 27.0 | 2004 | | |
| Greer (GSR) | 3R/21L parallel | 65.0 | 2010 | | |
| | 3L21R extension | 34.1 | 1999 | | |
| George Bush Intl (IAH) | 14R/32L extension | 8.0 | 2000 | | |
| | 8L/26R new parallel | 95.0 | 2002 | | |
| | 9R/27L parallel | n/a | n/a | | |
| Jacksonville (JAX) | 7R/25L parallel | 50.0 | 2011 | | |
| Kahului (OGG) | 2/20 extension | 40.0 | 1999 | | |
| Kansas City (MCI) | 1L/19R extension | 12.0 | n/a | | |
| Las Vegas (LAS) | 1L/19R reconstruction | 50.0 | 1997 | | X |
| Little Rock (LIT) | 4L/22R extension | 31.0 | 1998 | | X |
| Louisville (SDF) | 17R/35L parallel | 59.0 | 1997 | | X |
| Lubbock (LBB) | 8/26 extension | 5.0 | 2005 | | |
| Memphis (MEM) | 18L/36R new parallel | | 1997 | X | |
| | 18C/36C extension & reconst | 103.0 | 2000 | | |
| Miami (MIA) | 8/26 new parallel | 180.0 | 2002 | | |
| Midland (MAF) | 10/28 extension | 5.0 | 2008 | | |
| Milwaukee (MKE) | 7R/25L parallel | n/a | n/a | | |
| | 7L/25R extension | 1.9 | 1998 | | |
| Minneapolis (MSP) | 17/35 air carrier | 175.0 | 2003 | | |

## Table 3-2.

### New and Extended Runways – Completed in 1997, Under Construction, Planned, or Proposed

| Airport | Runway | Est Cost ($M) | Operational Date | Completed in 97 | Under Construction |
|---|---|---|---|---|---|
| Nashville (BNA) | 2E/20E parallel | n/a | n/a | | |
| | 2R/20L extension | n/a | n/a | | |
| New Orleans (MSY) | 18/36 near parallel | 400.0 | 2005 | | |
| | 10/28 parallel | n/a | n/a | | |
| Newark (EWR) | 4L/22R extension | n/a | 2000 | | |
| Norfolk (ORF) | 5R/23L parallel | 75.0 | 2005 | | |
| Oakland Metro (OAK) | 11R/29L parallel | n/a | n/a | | |
| | 11/29 extension | n/a | n/a | | |
| Oklahoma City (OKC) | 17L/25R extension | 8.0 | 2014 | | |
| | 17R/35L extension | 8.0 | 2014 | | |
| | 17W/35W parallel | 13.0 | 2004 | | |
| | 13/31 extension | 5.0 | 2005 | | |
| Orlando (MCO) | 17L/35R 4th parallel | 137.0 | 2002 | | |
| | 17R/35L extension | n/a | n/a | | |
| Palm Beach (PBI) | 9L/27R extension | 10.0 | 2000 | | |
| Philadelphia (PHL) | 8/26 parallel-commuter | 220.0 | n/a | | |
| | 9L/27R relocation | n/a | n/a | | |
| Phoenix (PHX) | 7/25 3rd parallel | 170.0 | 1999 | | |
| | 8L/26R extension | 7.0 | 2000 | | |
| Pittsburgh (PIT) | 4th parallel 10/28 | 150.0 | n/a | | |
| | 5th parallel 10/28 | n/a | n/a | | |
| Raleigh-Durham (RDU) | 5R/23L extension | n/a | 2005 | | |
| | 3rd parallel | n/a | n/a | | |
| Richmond (RIC) | 16/34 extension | 45.0 | 1997 | | X |
| Reno/Tahoe (RNO) | 7/25 extension | n/a | n/a | | |
| | 34R extension | n/a | n/a | | |
| Rochester (ROC) | 4R/22L parallel | 10.0 | 2010 | | |
| | 4/22 extension | 4.0 | 2000 | | |
| | 10/28 extension | 3.2 | 2000 | | |
| Lambert-St. Louis (STL) | New 12R/30L | 850.0 | 2003 | | |
| | 12R/30L extension | 50.0 | n/a | | |
| San Antonio (SAT) | 12L/30R reconstruction | 20.0 | 2010 | | |
| | 12N/30N new runway | 400.0 | n/a | | |
| San Jose (SJC) | 12L/30R extension | 16.0 | 1999 | | |
| Santa Ana(SNA) | 1/19R extension | n/a | n/a | | |
| Sarasota-Bradenton (SRQ) | 14L/32R parallel | 10.0 | 2002+ | | |
| | 14/32 extension | 5.1 | 2002+ | | |
| Savannah (SAV) | 9L/27R new parallel | 20.0 | 2020 | | |
| Seattle-Tacoma (SEA) | 16W/34W parallel | 585.0 | 2004 | | |
| Spokane (GEG) | 3L/21R | 11.0 | 2010 | | |
| Syracuse (SYR) | 10L/28R | 55.0 | n/a | | |
| Tampa (TPA) | 18W/36W 3rd parallel | n/a | n/a | | |
| | 9/27 extension | n/a | 2010+ | | |
| | 18L/36R extension | n/a | 2005+ | | |
| Tucson (TUS) | 11R/29L parallel | 30.0 | 2005 | | |
| Tulsa (TUL) | 18L/36R parallel | 115.0 | 2005 | | |
| Washington Dulles (IAD) | 1L/19R parallel | n/a | 2009 | | |
| | 12R/30L parallel | n/a | n/a | | |
| Total of Available estimated costs: | | $6,312.5M | | | |

n/a = no data available at press time

runway, 4,200 feet south of existing runway 9R/27L. A December 1995 update of the Airport Capacity Enhancement Plan showed this runway would provide significant delay savings benefits at ATL. The city of Atlanta is currently purchasing land for the new runway. Construction is expected to begin in early 1998 and be completed in early 2002. This runway will allow triple simultaneous arrivals to ATL in instrument conditions using the new Precision Runway Monitor (PRM) technology. A runway dedicated to commuter aircraft arrivals will reduce airborne delay for these aircraft and air carrier aircraft operating on the four existing runways. A reduction in delays at a major hub airport such as ATL will reduce delays in the entire NAS.

### Southwest Region

Due to the projected growth of handling one million operations annually before 2005, the Dallas/Fort Worth International Airport (DFW) is extending three of its seven runways and will begin construction of a new parallel runway, Runway 18R/36L (west of the existing north/south runways). This runway will significantly increase capacity in all weather conditions. The $208 million dollar project will be 5,800 feet from the closest runway and will allow independent approaches without PRMs. The runway is expected to be operational by 2003. DFW will be the first airport to offer four simultaneous parallel approaches and takeoffs under instrument conditions.

### Eastern Region

The City of Philadelphia is well underway with the construction of a fourth runway for Philadelphia International Airport. This is especially important in the light of recent enhancements to it's hub service levels.

## Airport Capacity Studies

As environmental, financial, and other constraints continue to restrict the development of new airports in the United States, increased emphasis has been placed on the redevelopment and expansion of existing airport facilities. The FAA's Office of System Capacity (ASC) forms Airport Capacity Design, Tactical Initiative, and Regional Design Teams to focus on maximizing the capacity at existing airports through improvements in runways and taxiways, navigational and guidance aids, and operational procedures. Table 3-3 lists the completed airport capacity, tactical initiative, and regional studies and the year in which they were published.[4]

As environmental, financial, and other constraints continue to restrict the development of new airports in the United States, increased emphasis has been placed on the redevelopment and expansion of existing airport facilities.

### Airport Capacity Design Teams

Airport Capacity Design Teams address capacity problems at airports with significant flight delays. The teams are composed of: FAA representatives from ASC, the Technical Center, Air Traffic, and the appropriate FAA Region; airport operators; airlines; general aviation; and other aviation industry representatives.

Airport Capacity Design Teams address capacity problems at airports with significant flight delays.

Airport Capacity Design Teams consider capacity improvement alternatives. Impacts of alternatives that are considered technically feasible are evaluated by computer simulation modeling (SIMMOD, RDSIM, ADSIM)conducted by the FAA Technical Center's Aviation Capacity Branch. The product of the study is a set of capacity-enhancing recommendations. Environmental, socioeconomic, and political implications, while not evaluated by the design teams, are addressed by the FAA and local authorities if and when the airport authority chooses to pursue one or more of the capacity enhancement alternatives.

The presence of a recommended improvement in a Capacity Enhancement Plan does not obligate the FAA to provide Facilities and Equipment (F&E) or AIP funds.

### Recommendations from Previous Airport Capacity Studies

Since 1985, more than 40 Airport Capacity Design Team studies have been conducted. The typical Airport Capacity Design Team considers 20 to 30 alternatives for increasing capacity. Table 3-4 lists completed airport capacity studies and their recommendations according to generalized categories of im-

Since 1985, more than 40 Airport Capacity Design Team studies have been conducted. The typical Airport Capacity Design Team considers 20 to 30 alternatives for increasing capacity.

4. Electronic copies of many of these reports can be obtained from the ASC world wide web site: http://www.asc.faa.gov

## Table 3-3.

### Completed Airport Capacity, Tactical Initiative, and Regional Design Studies

| Study | Date |
|---|---|
| **Capacity Enhancement Plans** | |
| Albuquerque Int'l | 1993 |
| Boston Logan Int'l | 1992 |
| Charlotte/Douglas Int'l | 1991 |
| Chicago Midway | 1991 |
| Chicago O'Hare Int'l | 1991 |
| Cleveland-Hopkins Int'l | 1994 |
| Dallas-Ft. Worth Int'l | 1994 |
| Detroit Metropolitan Wayne County | 1988 |
| Eastern Virginia Region | 1994 |
| Fort Lauderdale-Hollywood Int'l | 1993 |
| Greater Pittsburgh Int'l | 1991 |
| Hartsfield Atlanta Int'l | 1987 |
| Hartsfield Atlanta Int'l Update | 1995 |
| Honolulu Int'l | 1992 |
| Houston Intercontinental | 1993 |
| Indianapolis Int'l | 1993 |
| Kansas City Int'l | 1990 |
| Lambert St. Louis Int'l | 1988 |
| Las Vegas McCarran Int'l | 1994 |
| Los Angeles Int'l | 1991 |
| Memphis Int'l | 1988 |
| Memphis Int'l Update | 1997 |
| Miami Int'l | 1989 |
| Minneapolis-Saint Paul Int'l | 1993 |
| Nashville Int'l | 1991 |
| New Orleans Int'l | 1992 |
| Oakland Int'l | 1987 |
| Orlando Int'l | 1990 |
| Philadelphia Int'l | 1991 |
| Phoenix Sky Harbor Int'l | 1989 |
| Port Columbus Int'l | 1993 |
| Portland Int'l | 1996 |
| Raleigh-Durham Int'l | 1991 |
| Salt Lake City Int'l | 1991 |
| San Antonio Int'l | 1992 |
| San Francisco Int'l | 1987 |
| San Jose Int'l | 1987 |
| San Juan Luis Muñoz Marín Int'l | 1991 |
| Seattle-Tacoma Int'l | 1991 |
| Seattle-Tacoma Int'l Update | 1995 |
| Washington Dulles Int'l | 1990 |
| **Tactical Initiatives** | |
| Charlotte Douglas Int'l | 1995 |
| Los Angeles Int'l (Commuter Gates) | 1996 |
| Los Angeles Int'l (TBIT Expansion) | 1993 |
| New York La Guardia Airport | 1994 |
| Orlando Int'l | 1995 |

## Table 3-4.

### Completed Airport Capacity Studies and Recommendations

√ Recommended
C Completed
⊗ No Longer Under Consideration

| Airports / Recommended Improvements[1] | Airfield Improvements | Construct third parallel runway | Construct fourth parallel runway[2] | Relocate runway | Construct new taxiway | Runway extension | Taxiway extension | Angled exits/improved exits | Holding pads/improved staging areas | Terminal expansion | Facilities and Equipment Improvements | Install/upgrade ILSs | Install/upgrade RVRs | Install/upgrade lighting system | Install/upgrade VOR | Upgrade terminal approach radar | Install ASDE | Install PRM | New air traffic control tower | Wake vortex advisory system | Operational Improvements | Airspace restructure/analysis | Improve IFR approach procedures | Improve departure sequencing | Reduced separations between arrivals | Intersecting operations with wet runways | Expand TRACON/Establish TCA | Segregate traffic | De-peak airline schedules | Enhance reliever and GA airport system |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Albuquerque | | | | | C | C | C | C | √ | √ | | C | | | √ | | | | | | | | √ | | √ | | | | | √ |
| Atlanta (Update Study) | | | √ | | | | | √ | √ | √ | | √ | | | | | | √ | | √ | | | | | √ | | | | ⊗ | √ |
| Boston | | | | | ⊗ | ⊗ | ⊗ | √ | C | | | √ | | | | | | | | √ | | | C | | | √ | | | | |
| Charlotte-Douglas | | | | | | C | √ | C | √ | | | √ | | √ | | | √ | √ | | | | | | | | √ | C | | | √ |
| Chicago Midway | | | | | √ | C | | | C | C | | | | | | | | | | | | | √ | | √ | | | | | |
| Chicago O'Hare | | | | √ | ⊗ | √ | | C | C | | | C | | | | | | | | | | | √ | | | C | | | | |
| Cleveland | | ⊗ | | √ | √ | √ | √ | √ | | √ | | √ | | | √ | | | √ | | | | | √ | √ | √ | | | | | √ |
| Dallas-Ft. Worth | | | | | C | √ | | C | | | | | | | | | | | | | | | C | C | C | | | | | C |
| Port Columbus | | √ | ⊗ | √ | √ | √ | | √ | √ | √ | | √ | | √ | | | √ | √ | √ | | | √ | √ | | √ | | | | √ | √ |
| Fort Lauderdale | | | | | √ | ⊗ | | √ | √ | √ | | √ | | | √ | C | | √ | | √ | | √ | √ | | √ | | | | √ | √ |
| Honolulu | | √ | | | | √ | | √ | √ | √ | | √ | | | | | | | | | | | | | | | | | √ | C |
| Houston Intercontinental | | √ | √ | | √ | √ | | √ | √ | √ | | √ | | | | | | | | | | | √ | | | | | | √ | √ |
| Indianapolis | | √ | √ | C | √ | | | √ | √ | | | √ | √ | √ | | | √ | | | | | | √ | | √ | | | | | √ |
| Kansas City | | √ | ⊗ | | | | C | √ | √ | √ | | √ | √ | | | | C | | | | | | √ | | √ | | | | √ | |
| Las Vegas | | | | | √ | C | C | | C | √ | | √ | | | | | | | | | | | √ | | | √ | | | | C |
| Los Angeles | | | | | C | √ | C | √ | C | √ | | C | | | | | | | C | | | √ | | | | | | | | |
| Memphis Update | | | | | √ | √ | √ | √ | √ | | | √ | | | | | | √ | | √ | | | C | | √ | | | | √ | √ |
| Miami | | | | | C | | √ | C | C | | | C | C | C | | | C | | | | | | C | | | | | | | C |
| Minneapolis-Saint Paul | | √ | | | √ | √ | | √ | √ | √ | | √ | √ | √ | √ | | | √ | | | | √ | | | √ | | | | | √ |
| Nashville | | | √ | C | C | √ | √ | | √ | | | C | | | | | | | | √ | | C | √ | | | | √ | | ⊗ | √ |
| New Orleans | | | | | C | | | | | | | | | | √ | | | | C | | | √ | C | | C | | | | | C |
| Newport News | | | | | | √ | | √ | | | | | | | | | | | | | | | √ | | √ | | | | | |
| Norfolk | | | | | | √ | | | | | | √ | √ | √ | | | | | | | | | | | √ | | | | | |
| Oakland | | | | | √ | | | √ | √ | | | | | | | | | | | | | | | | | | | | | |
| Orlando | | | √ | | √ | | C | | √ | | | √ | | | √ | | √ | √ | | | | C | √ | | | | | √ | | √ |
| Philadelphia | | √ | | √ | | √ | | | | | | | | | | | | √ | | | | √ | √ | √ | | | | | | |
| Phoenix | | √ | | | √ | | C | √ | C | C | | C | | √ | C | | | | | | | | √ | √ | √ | | | √ | √ | C |
| Pittsburgh | | | √ | | | C | | | | √ | | C | | | | | | √ | | | | √ | | | | | | | | |
| Portland | | | | | √ | | √ | √ | | | | √ | | | | | | | | | | | √ | √ | √ | | | √ | | |
| Raleigh-Durham | | √ | ⊗ | ⊗ | √ | | | √ | √ | | | √ | √ | | | | √ | | | √ | | √ | √ | | √ | | √ | | | |
| Richmond | | | | | | √ | | √ | | | | √ | √ | √ | | | | | | | | | √ | | √ | | | | | |
| St. Louis | | √ | | | | | C | √ | √ | | | √ | | √ | | | C | | | √ | | | C | | C | | | | ⊗ | |
| Salt Lake City | | C | | | | | C | C | √ | √ | | C | C | C | | | C | √ | | | | | C | | C | | | | | √ |
| San Antonio | | √ | | | √ | √ | √ | | C | | | C | C | √ | | | | √ | | √ | | √ | √ | | √ | | | | | √ |
| San Fransisco | | ⊗ | ⊗ | | | √ | C | √ | √ | | | | | | | | | | | | | | | C | | | | | √ | C |
| San Jose | | | | | | C | | C | C | | | | | | | | | | | | | | | C | | | | | | |
| San Juan, Puerto Rico | | | | | √ | | √ | √ | √ | √ | | | | √ | √ | | | | C | √ | | | | | √ | | | | | √ |
| Seattle-Tacoma | | √ | | | | | | C | | | | √ | | | | | | | | √ | | | √ | | C | | | | ⊗ | |
| Washington-Dulles | | √ | | | C | C | C | | C | √ | | | C | C | | | | | | | | | C | | C | | | | ⊗ | ⊗ |

1. Recommendations summarized and grouped in generalized improvement categories.
2. Construct fifth parallel runway in the case of Atlanta.

provements. The table indicates those recommendations that have been implemented, completed, or are no longer under consideration.

Airfield improvements were recommended for all of the airports studied. Common airfield recommendations include building or extending runways and taxiways and improving exits and staging areas to increase the efficiency of existing runways. At least one of the recommended airfield improvements has been completed at 25 of the airports studied. Airfield improvements such as construction of new runways and runway extensions may take more than ten years from proposal to completion due to financing constraints and the need to study and address environmental concerns.

Common recommendations for improving F&E are the installation or upgrade of Instrument Landing Systems (ILS) to improve runway capacity during IFR operations and the installation of Runway Visual Range (RVR) and approach lighting systems. Improvements to F&E and operations are generally less expensive and time consuming to implement than airfield improvements. However, like airfield improvements, the ability to implement F&E recommendations is contingent upon available financing. F&E improvements such as the installation of RVRs and approach lights generally coincide with the completion of a new runway or runway extension.

Common procedural recommendations include improved IFR approach procedures and reduced separation standards for arrivals. Enhancement of the reliever and general aviation airport system is also a frequent recommendation for moderating the demand on a given airport. Improved IFR approach procedures and reduced separations between arrivals have been implemented at several of the airports studied by the Capacity Design Teams.

## 1997 Airport Capacity Design Team Studies

Airport Capacity Design Team studies, or updates of previous studies, in progress or completed in 1997, are summarized below.

### Reno/Tahoe International Airport (RNO)

Reno has experienced steady and sustained growth over the last decade. As a result, passenger enplanements more than doubled from 1.4 million in 1983 to 2.9 million in 1995. Therefore, in February 1995 an Airport Capacity Design Team for RNO was formed. Capacity enhancing alternatives considered include the construction of a new apron, a new concourse, de-icing facilities, and runway and taxiway extensions. Possible F&E improvements include development of precision approaches and the installation of Doppler radar and RVR systems. Procedural improvements include adoption of land and hold short procedures (LAHSO), and a 2.5 nm in-trail separation. Publication of this study is scheduled for 1998.

### Memphis International Airport Update (MEM)

Memphis International Airport is the 25th busiest airport in the country when ranked by 1996 aircraft operations. MEM has experienced steady, sustained growth over the past five years as operations increased 5.6 percent and enplanements increased more than 15 percent. MEM is ranked as the number one air cargo airport in the world for the fifth consecutive year. If improvements are not made, continued traffic growth will cause more than 20,000 hours of annual delay through 2006.

In 1995 ASC began an update to the 1988 Capacity Enhancement Plan. The update was initiated in light of the fact that a new runway was to be commissioned in December 1996, and soon after, an existing runway would be closed for reconstruction. The design team's primary goals were to provide input for the Memphis Master Plan update and use computer modeling to determine how to maximize use of the new operational third parallel runway, while existing runways are being reconstructed. The Memphis International Airport Capacity Enhancement Plan Update was completed during 1997 and the most significant recommendations include:

- Extend Runway 18C/36C to the south to 11,100 feet to accommodate non-stop long range flights;
- During reconstruction of Runway 18R/36L, operate Taxiway M as an air carrier runway with arrivals and departures in north and south flow during visual flight rules (VFR) only;
- Extend Taxiway N to the full length of existing Runway 18R/36L to provide improved access to Runway 36L and provide temporary service to Taxiway M while being used as an active runway.

### Miami International Airport Update (MIA)

When ranked by aircraft operations, MIA is fifth on the list of the 100 busiest airports in the U.S. In the past five years, MIA experienced a 28 percent increase in passenger enplanements and a 12.4 percent increase in operations. MIA will continue to experience more than 20,000 hours of annual delay through the year 2006 if no capacity improvements are made. The update to the 1989 Capacity Enhancement Plan for MIA was initiated in

September 1995 in response to traffic growth and the need to further analyze capacity enhancement alternatives. The capacity design team reassessed some previously recommended improvements and considered potential new improvements to increase MIA's capacity. The team analyzed a new, closely-spaced parallel runway and a reconfigured terminal and conducted an airfield study. The MIA study is scheduled for publication in 1998.

### Newark International Airport (EWR)

A study of Newark began in November 1996. The Design Team is investigating the effect of a runway extension that will intersect the crosswind runway and other short term improvements such as approaches to other airports using EWR's Differential Global Positioning System (DGPS). The team is also studying innovative approach procedures to the converging runway and innovative dual approach procedures to the closely spaced parallel runways. The EWR study will be published in FY98.

## 1997 Tactical Initiative Teams

Tactical Initiative Teams focus on providing immediate relief to airports with chronic delay. The recommendations of Tactical Initiative Teams generally focus on procedural changes that can be implemented quickly with little financial investment. Ongoing Tactical Initiative projects in 1997 are summarized below.

### San Diego International Airport (SAN)

The San Diego study began in May 1996; the expected completion date is late 1998. The Tactical Initiative Team has been investigating the effect of another terminal, ground flow and other short term improvements such as an additional terminal concourse, taxiway development, and remote aircraft parking areas already approved in the Immediate Action Plan. The study analyzes major airfield improvement concepts developed in the 1997 airport Master Plan study.

### Las Vegas McCarran International Airport (LAS)

LAS is adding another gate complex, Terminal D, to the airport. Construction on this terminal is underway. The FAA is examining the impacts of an initial increase in traffic on existing taxiways and gates. In addition, the ability of the new terminal complex to accommodate future traffic levels will be tested. Other issues such as off-gate and overnight parking will also be examined. This new study is an extension of the previous Las Vegas study completed in 1994. The expected completion date is February 1998.

## 1997 Regional Capacity Design Teams

Looking beyond the individual airport and its immediate airspace, the Office of System Capacity plans regional studies. Regional Capacity Design Teams analyze all the major airports in a metropolitan or regional system and model them in the same terminal airspace environment. This regional perspective explores how capacity-producing improvements at one airport will affect air traffic operations at other airports and within associated airspace.

### Northeast Region Capacity Design Study

The Northeast Region study, which began in September 1996, was initiated to analyze the impacts of the decentralization of northeastern airports as passengers migrate from the primary airports (BOS, EWR, JFK, and LGA) for each metropolitan area. The Design Team is working with the Volpe National Transportation Systems Center to study the effect of increased passenger traffic at the outlying airports in both the New York and Boston areas.

### Anchorage Area Airspace Design Team Study

The Anchorage Area Airspace Design Team Study will identify ways to best accommodate existing and future aircraft operations in the Anchorage area. The study is expected to last 18 months and involves four major airports: Anchorage International (ANC), Lake Hood, Merrill Field, and Elmendorf. Additionally, the private use airports and heliports in the Anchorage area will be included in the study.

The study's complexity is heightened by multiple airport interaction and the strong presence of GA aircraft in Alaska and the Anchorage area — Lake Hood is the busiest seaplane facility in the world, and Merrill Field is one of the busiest GA airports in the world. Obtaining representative data on those GA users who do not use air traffic control services adds an additional degree of complexity to this study.

As the scope of the study is being defined, the following considerations are being evaluated: the impact on operations in the Anchorage area of constructing a new runway and runway extension; innovative approach procedures to the converging runway at ANC and to the closely spaced parallel runways; and means of addressing congestion problems caused by more than one million annual operations transiting over Point McKenzie, a single fix.

# CHAPTER 4: AIRSPACE DEVELOPMENT

Airspace development studies strive to relieve congestion and reduce system delay by determining how to: restructure airspace; reroute traffic; or modify arrival, departure, or en route and terminal flow patterns. En route airspace studies may extend to one or more Air Route Traffic Control Centers (ARTCCs), encompassing traffic flowing into and out of several airports. In contrast, terminal airspace studies address only the terminal area, usually encompassing about a 40 mile radius around the airport.

En route airspace studies may be prompted by experienced or projected congestion and delays, airport development, improved operational procedures, or resectorization of the airspace that provides opportunities to modify traffic flow. From the analysis stage to implementation, major redesign of en route airspace is a complex process that may take up to ten years. En route airspace capacity studies are conducted jointly by the Office of System Capacity (ASC), Air Traffic (AAT), and the Office of Environment and Energy (AEE).

Terminal airspace studies, generally intended to follow Airport Capacity Design Team studies, examine ways to ensure that the airport's airspace can most efficiently accommodate new traffic patterns resulting from new runways and runway extensions and projected traffic increases. Terminal airspace studies are typically conducted by the Airport Capacity Design Team that conducted the airport capacity enhancement study, with the assistance of the FAA Technical Center and additional Air Traffic representatives. Table 4-1 lists completed en route and terminal airspace studies.

Table 4-2 lists the various alternatives proposed for improving traffic flow for each airspace region. Common airspace improvement alternatives include: relocating arrival fixes, creating new arrival and departure routes, modifying ARTCC traffic flows, and redefining Terminal Radar Approach Control (TRACON) boundaries.

This chapter describes ongoing and recently completed en route and terminal airspace studies. It concludes with a short description of the FAA's involvement in a relatively new airspace frontier, commercial space.

## Table 4-1.

### Completed En Route and Terminal Airspace Studies

**Terminal Airspace**
Houston Intercontinental
Minneapolis-St. Paul Int'l
San Bernardino/Ontario

**En Route Airspace**
Chicago
Dallas-Ft. Worth
Denver
Expanded East Coast Plan
Houston-Austin
Kansas City
Los Angeles
Oakland
New York
Jacksonville
Atlanta
Miami

## Table 4-2.

### Airspace Design Alternatives by Airspace Region

| Studied Alternatives / Airspace Regions | Chicago | Dallas-Ft. Worth | Denver | Expanded East Coast Plan | Houston-Austin | Kansas City | Los Angeles | Oakland | New York | Jacksonville | Atlanta | Miami |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Relocating arrival fixes | √ | √ | | | | √ | | | | | √ | |
| New arrival routes | | √ | √ | √ | √ | √ | | √ | √ | √ | √ | √ |
| New departure routes | √ | | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Modifications to ARTCC traffic | | √ | | √ | √ | √ | √ | √ | √ | √ | √ | |
| New airport | | | √ | | √ | | | | | | | |
| Hub/non-hub alternatives | | | | | √ | | | | | | | |
| Change in metering restrictions | √ | | | √ | | | | √ | | | | √ |
| Redifining TRACON boundaries | | √ | | √ | √ | | √ | √ | | | √ | |
| Redifining sector ceilngs | | | | | | | | | √ | √ | √ | |
| Resectorization | | | | | | | | | √ | √ | √ | √ |
| Military traffic considered | | √ | | | √ | | √ | √ | | | | |
| New runways at existing airports | √ | √ | | | | √ | | | | | | |
| Specific modeling of 2 or more airports for interactions analysis | √ | √ | | | | √ | | | √ | √ | √ | √ |

## Ongoing Airspace Studies

ASC is currently involved in en route airspace studies in three regions of the country: Chicago; the west coast, including northern California, southern California and Las Vegas; and Salt Lake City. ASC is also conducting a terminal airspace study at Phoenix International Airport.

### Chicago Metroplex Airspace Analysis

The purpose of this project is to increase the efficiency of existing airport capacity by redesigning arrival and departure routes and using a new TRACON with an updated area route terminal system (ARTS) to improve airspace traffic flow. The study area consists of the Chicago Center, which includes traffic operations within Chicago and Milwaukee TRACONs, and en route portions of the four adjacent ARTCCs.

The FAA identified the time and location of traffic bottlenecks and other constrained operations by animating traffic flows, computing traffic count statistics, and computing time and distance relationships. Figure 4-1 illustrates the arrival paths for Chicago O'Hare International Airport (ORD). Wavering flight paths indicate that flights were path-stretched by air traffic controllers to regulate traffic flow approaching the terminal area.

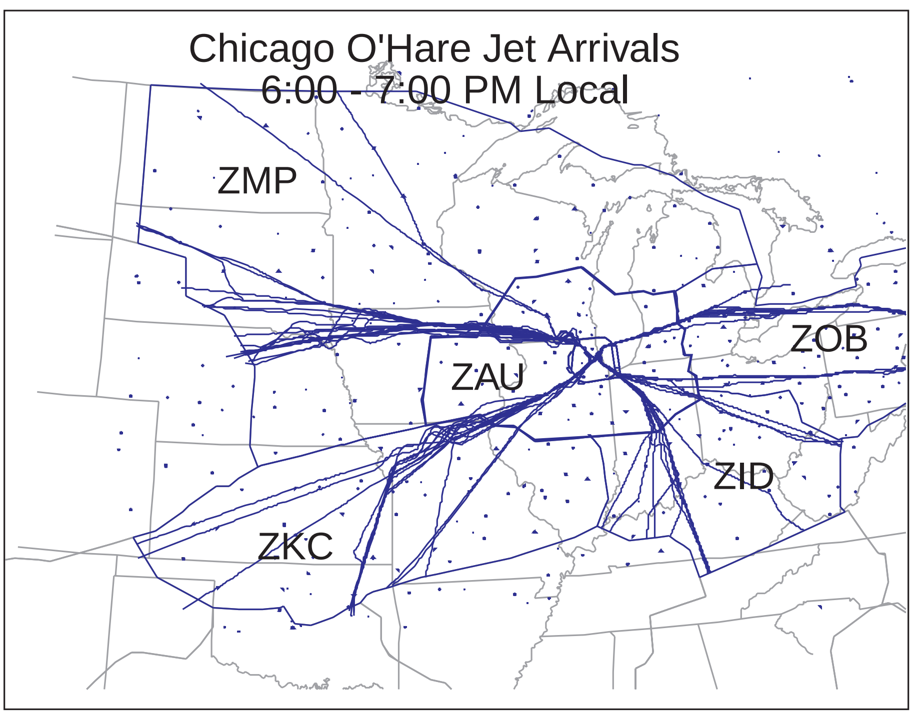



**Figure 4-1.**

Flight Paths Over Five-Center Area

After extensive analysis, three airspace design alternatives were developed that would provide an airspace structure to increase airspace capacity for O'Hare International arrivals. The first alternative is to add four arrival routes to Chicago's TRACON for ORD arrivals. During heavy traffic periods, two additional dual routes (Alternative 1A) or one dual route (Alternative 1B) could be activated as required. The second alternative is to rotate the existing four corner posts by 45 degrees, allowing redistribution of traffic flow and an additional arrival fix from east and west. The third alternative is to establish two additional arrival corner posts (totaling six) for ORD arrivals. Figure 4-2 is a simplified diagram illustrating the basic routing concepts behind the proposed alternatives. For each alternative, the projected annualized dollar savings resulting from the reduced flight time at the baseline traffic level is presented.[1] The FAA is currently conducting analyses of the likely environmental impacts.

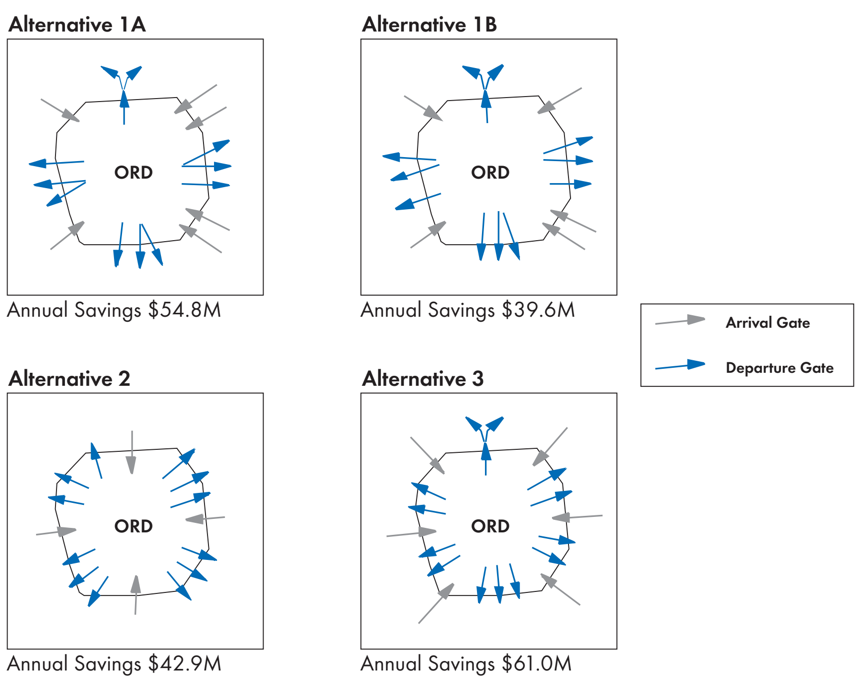



**Figure 4-2.**

Airspace Design Alternatives for Chicago

1. All aircraft operating costs savings quoted in this chapter are based on marginal aircraft operating cost of $1,600 per hour.

## West Coast Airspace Analysis

ASC is involved in a large-scale analysis of the airspace on the west coast of the United States, ranging from San Francisco/ Oakland in the north, to Los Angeles in the south, and extending to Las Vegas to the east.

In California, the airspace of two major new facilities, the Southern California TRACON (SCT) and the Northern California TRACON (NCT), are being analyzed to capitalize on potential efficiency and capacity gains made possible by the new facilities. The SCT controls terminal airspace in the Los Angeles-San Diego area and consolidates the operations of the former Los Angeles, Coast, Burbank, Ontario, and San Diego TRACONs into a single facility. The NCT (which has been proposed but not yet constructed) will control airspace in San Francisco, Sacramento, and their surrounding areas. The consolidation and expansion of the airspace surrounding San Francisco into the NCT will enhance controller flexibility for merging and sequencing aircraft to and from northern California. The FAA has developed proposals for streamlining the coastwise traffic flow while addressing the long-haul traffic problems specific to each facility.

### SCT Airspace Analysis

Over the last year, the FAA developed airspace alternatives to address traffic movement problems within the Los Angeles Basin area. An Arrival Enhancement Procedure (AEP) for Los Angeles International Airport (LAX) would provide dual arrival streams for flights landing at LAX from the east. Figures 4-3 and 4-4 show a comparison of flight tracks for the existing landing procedure and the proposed traffic flows under the AEP alternative, respectively. Currently, traffic from the east and northeast merge into a single flow over CIVET for sequencing to Runway 25L at LAX. Under the AEP, the path for flights arriving from the northeast would remain unchanged. Flights arriving from the east would be rerouted to GEORG, REBCA, PDZ, and ARNES, then to Runway 25L. The new arrival route would remove pressure on CIVET and reduce congestion related delays. Annualized cost savings due to reduced flight times as a result of the AEP are projected to be $13.3 million at baseline traffic levels. By 2005, savings are expected to increase to $64.9 million annually.

### NCT Airspace Analysis

Two FAA proposals for enhancing airspace efficiency in northern California are: an offshore standard terminal arrival route (STAR) for Oakland Airport (OAK), to remove Oakland-bound

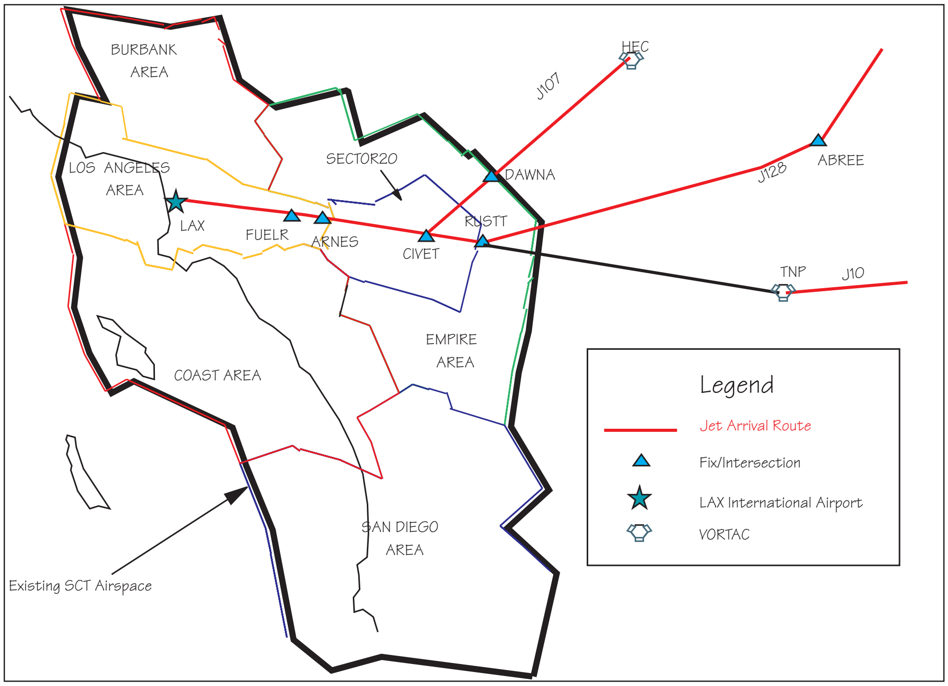



**Figure 4-3.**

Existing Routes to Los Angeles International Airport

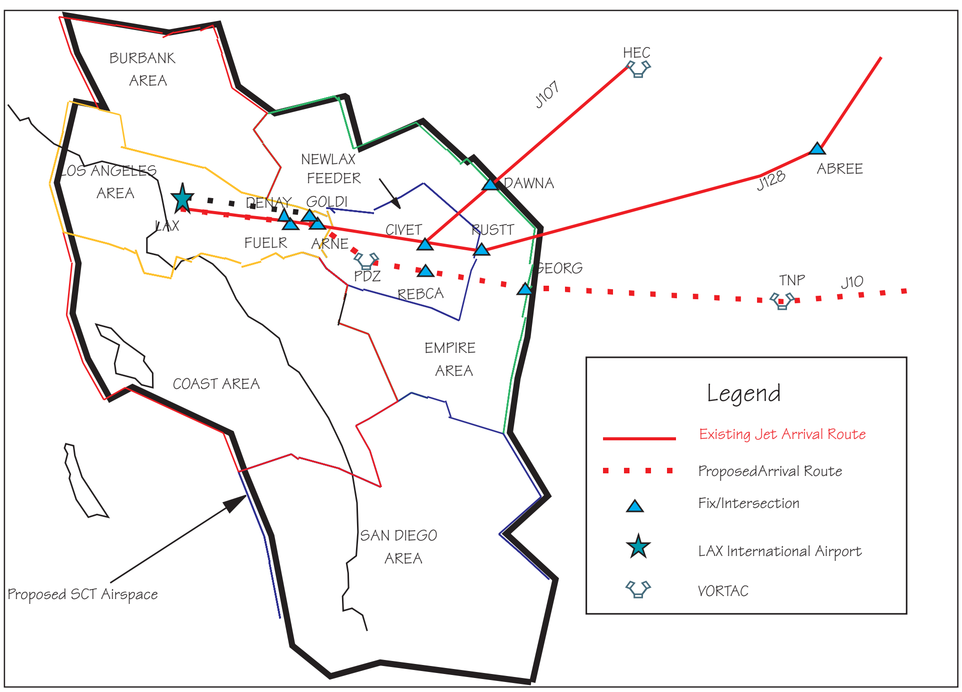



**Figure 4-4.**

Proposed Arrival Enhancement Procedure (AEP) to Los Angeles International Airport

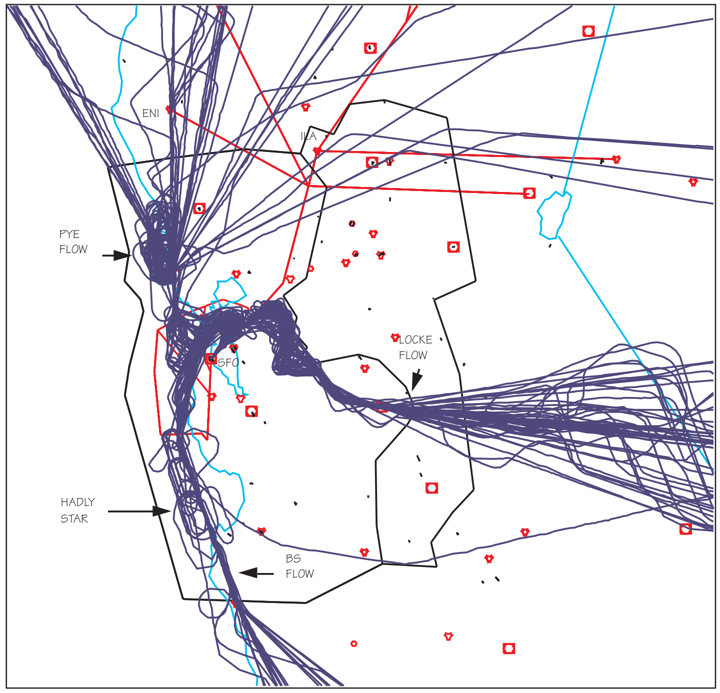



**Figure 4-5.**

Flight Tracks of SFO Arrivals

traffic from the San Francisco arrival stream; and a straight-in STAR for northwest arrivals to San Francisco International Airport (SFO).

Figure 4-5 illustrates the flight paths of aircraft arriving to SFO over a six-hour period. The distended and circular flight paths for northbound flights approaching SFO and OAK are evidence of spacing techniques used by air traffic controllers to moderate traffic in the terminal areas. To reduce congestion in the northbound traffic, the FAA is considering segregating northbound SFO and OAK traffic by establishing an offshore STAR for flights bound for OAK.

Currently, most air traffic from the north, northwest, and northeast is routed over PYE (an arrival fix at Point Reyes) on approach to SFO. Due to congestion, traffic over PYE frequently must be path-stretched for sequencing into SFO. The FAA is studying the development of a new, straight-in STAR for SFO arrivals over UPEND, an initial approach fix for runway 19L. Implementation of the straight-in STAR is dependent on the consolidation and expansion of the airspace surrounding SFO into the NCT to enhance controller flexibility for merging and sequencing of aircraft. The new STAR would reduce average route distance for SFO arrivals by nearly 40 miles. Annual aircraft operating cost savings resulting from the SFO straight-in and OAK offshore STARs are estimated at $6.6 million at baseline traffic levels.

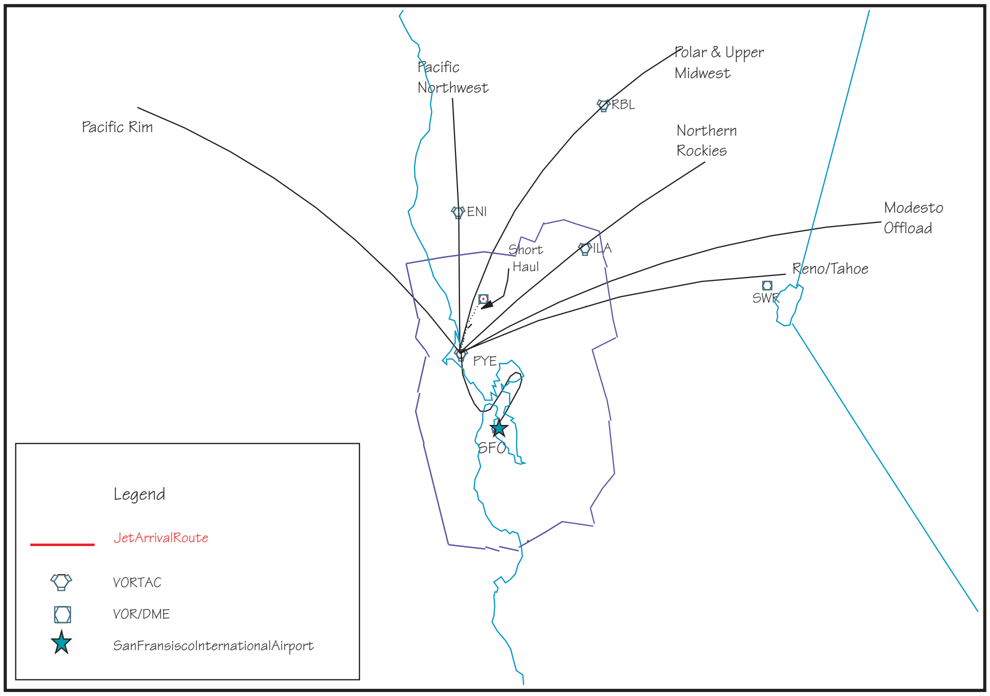



**Figure 4-6.**

Region of Origin and Existing Routings for SFO Arrivals

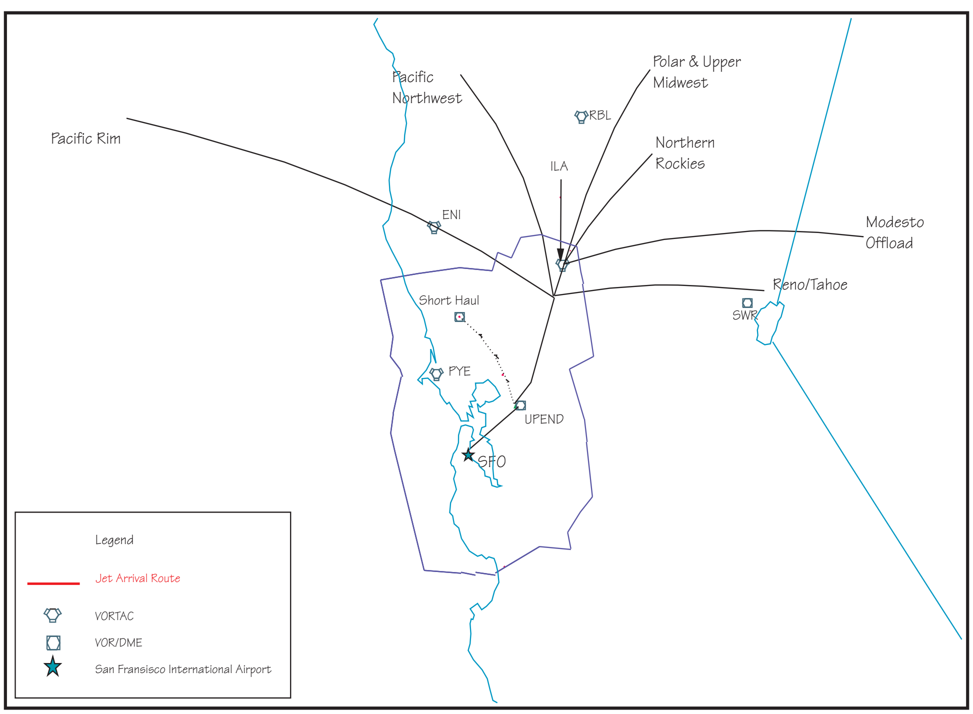



**Figure 4-7.**

Region of Origin and Routings for Proposed Straight-In star for SFO Arrivals

Figures 4-6 and 4-7 show a comparison of existing routings of SFO arrivals over PYE and the proposed rerouting of aircraft over UPEND under the straight-in STAR, respectively.

### Las Vegas Airspace Analysis

In 1995, Las Vegas had 29 million tourists. Of these, over 14 million traveled by air. By 1997, the number of tourists increased to more than 34 million, with more expected as new hotel rooms continue to be built. The consistent increase in visitors to Las Vegas has strained the operations at McCarren International Airport (LAS), which experienced more than 20,000 hours of delay in 1996, and for which continued delays are projected if no capacity improvements are made. Currently, LAS is constructing an additional 60 gates, which will more than double the number of existing gates. Although one runway is being upgraded, this improvement will probably not be sufficient to accommodate projected demand. To relieve pressure on LAS, most VFR sightseeing tour operations have been moved to North Las Vegas Airport (NLV).

The Las Vegas airspace analysis encompasses the airspace of the Los Angeles Center, including LAS and NLV. Computer analysis was used to design alternative arrival and departure routings in conjunction with modified runway use to enable the FAA to better service the dramatic growth in air traffic demand in the Las Vegas area. The study also assesses how best to route tour flights so that they are compatible with other flights within the Las Vegas TRACON and how moving tour operations to NLV has affected operations at LAS.

A proposed corner post structure for LAS arrivals and the establishment of dedicated arrival and departure runways could result in substantial flight-time savings. The proposed airspace changes would result in daily flight-time savings of 65 hours at current traffic levels; aircraft delays of greater than 15 minutes would be reduced by 82 percent. At anticipated traffic levels, projected delay savings are even more pronounced.

## Salt Lake City Airspace Analysis

Air traffic activity at the Salt Lake City Airport (SLC) has increased significantly in the past few years, from 317,000 operations in 1992 to 374,000 operations in 1996. SLC is a hub for Delta and SkyWest Airlines. Federal Express is in the process of building a cargo hub operation there. SLC experienced more than 20,000 hours of delay in FY96, and if no further capacity enhancements are made, will continue to exceed 20,000 hours of delay annually (see Table 1-5). The Salt Lake City airspace analysis began in April 1997. The purpose of the study is to reduce traffic flow complexity to accommodate expected traffic growth, including traffic growth projections for the upcoming 2002 Winter Olympic games. Routing options for SLC are limited by the presence of military special use airspace to the west of the airport, and mountainous terrain to the east.

Airspace analysis and modeling tools were used to create graphic displays of existing flight tracks to assess current airspace operations within Salt Lake Center and portions of Denver Center. Under the existing air traffic structure, certain sectors handle both arrivals and departures, which is not ideal from a workload and safety standpoint. Figure 4-8 shows the current arrival tracks and departure routes for SLC. The FAA developed an improved corner post structure for arrivals in conjunction with additional downwind legs for the purpose of increasing runway throughput, and redefined sector boundaries. Figure 4-9 shows the proposed resectorization and arrival and departure structure. Restructuring of the en route airspace will allow refinements of air traffic control in the terminal airspace, thus generating additional capacity gains.

### Phoenix Terminal Airspace Analysis

Due to a significant increase in operations, a Terminal Airspace Study has been initiated in Phoenix. The study, which also involves the Albuquerque Center, began in the fall of 1997. This team is addressing the expected increase of arrival and departures in the Phoenix area.

## Commercial Space Transportation

The FAA regulates the U.S. commercial space transportation industry, licenses commercial launches and launch sites, and manages the airspace required for commercial launches to assure safety. Most commercial space launches contain communications, scientific, weather, or remote sensing satellites. Launches are financed by private corporations, states, Air Force grants, and NASA. Unlike airports, where the FAA builds and maintains air traffic control facilities, the FAA has no infrastructure at launch sites.

As of November 1997, there have been 81 licensed launches; all but one have launched from one of the following Federal sites: Cape Canaveral, White Sands Missile Range, Vandenberg, Wallops Island, and Barking Sands, Hawaii.

In September 1996, the FAA issued the first non-Federal space launch site license to the California Spaceport. In May 1997, the FAA issued a license to the Space Florida Authority. The FAA is

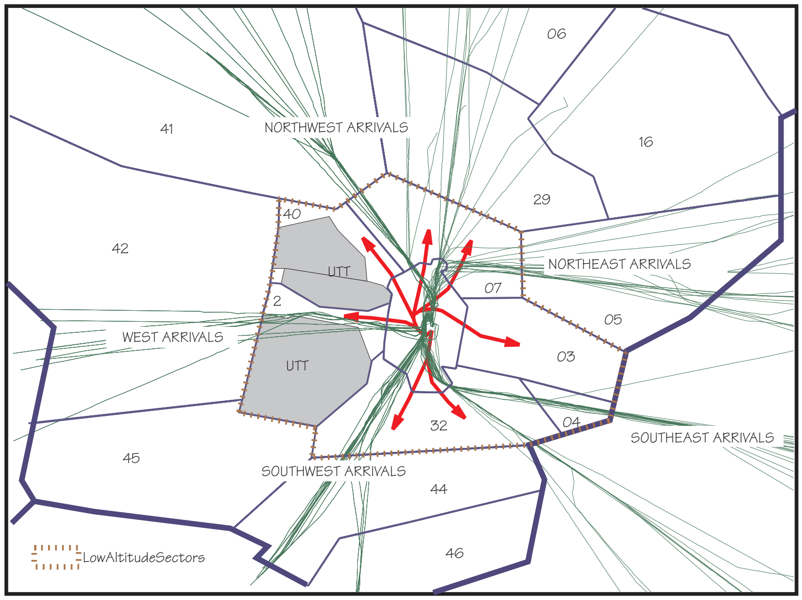



Figure 4-8.

Current Arrival Tracks and Departure Routes for SLC

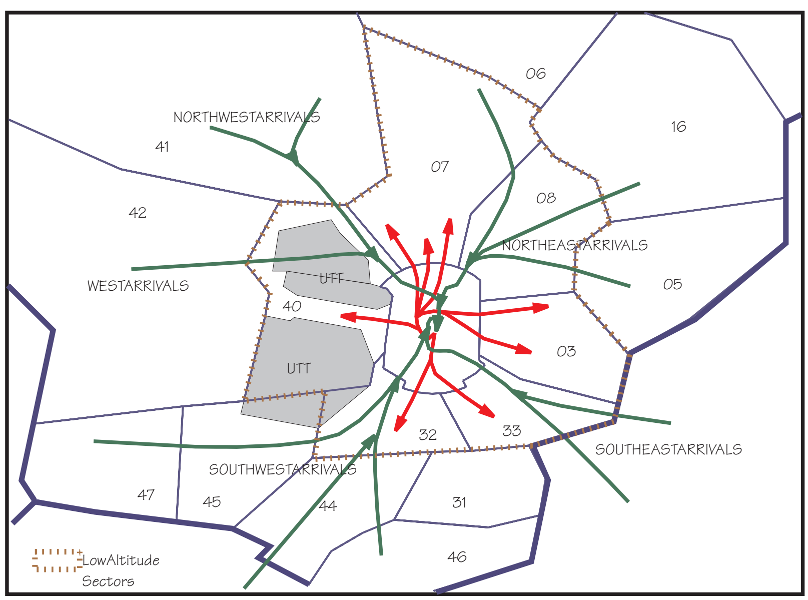



Figure 4-9.

Proposed Arrival and Departure Routes for SLC also working with Alaska, Nevada, New Mexico, and Virginia on other proposed commercial launch sites. The FAA is preparing regulations for licensing commercial launches and launch sites.

The FAA Office of Commercial Space Transportation is currently leading a program to analyze airspace requirements for launch and reentry of space vehicles. This project, which began in early 1977, will focus on the current practice of using SUA and refining the amount of airspace required during a launch or reentry. The first part of the study includes an analysis of the SUA required for the space shuttle.

# CHAPTER 5: NEW OPERATIONAL PROCEDURES

This chapter describes new and developing air traffic control procedures requiring minimal or no investment in new technology. Many of these developments are free flight initiatives that will give pilots more flexibility in determining their routes, altitude, speed, and departure and landing times. Modernization of the National Airspace System (NAS) equipment over the next decade will provide additional opportunities to develop procedures that take advantage of new technological capabilities. The procedures described in this chapter are listed below.

## En Route Procedures

- Direct routing
  - Area Navigation (RNAV)
  - Continue expansion of the National Route Program (NRP)
  - Reduce the number of Air Traffic Control (ATC)-Preferred Routes
  - Improved civilian access to Special Use Airspace (SUA)
- New guidelines for imposing restrictions

## Oceanic En Route Procedures

- Reduced Vertical Separation Minima (RVSM)
- Reduced Horizontal Separation Minima (RHSM)
- In-Trail Climb and In-Trail Descent
- Dynamic Aircraft Route Planning (DARP)

## Terminal Area/Approach Procedures

- RNAV approaches
- Simultaneous converging instrument approaches
- Removal of 250 knot speed limit below 10,000 feet in Class B airspace

## En Route Procedures

New en route procedures give airspace users more flexibility to determine their routes, altitude, and speed.

### Direct Routing

The ability of pilots to plan and fly direct routes is being improved through several procedural initiatives.

#### Area Navigation (RNAV)

Most aircraft today have equipment that enables them to fly direct routes using a procedure known as RNAV. RNAV is a generic term that refers to any instrument navigation performed outside of conventional routes — routes defined by the ground-based navigational aids or by intersections formed by two navigational aids. Technologies such as Flight Management Systems (FMS), LORAN-C, and inertial guidance systems have offered RNAV capability to aircraft, especially commercial carriers, for nearly two decades. With the introduction and widespread acceptance of Global Positioning System (GPS) to civilian aviation in the 1990s, even more aircraft have acquired this capability.

To make greater use of RNAV capabilities in terminal airspace, the FAA has begun to develop RNAV arrival and departure procedures for the top 50 airports.

While RNAV offers the potential for more flexibility and greater airspace efficiency, its use is often restricted by air traffic control procedures that are based on established route structures. This is the case in high-density terminal airspace where air traffic controllers rely on the use of standard instrument departures (SIDs) and standard terminal arrival routes (STARs) to align and sequence traffic. While possible, it is difficult for controllers to simultaneously accommodate non-standard RNAV arrival and departure procedures with SIDs and STARs. For this reason, RNAV arrival and departure routes are typically restricted to periods of low traffic.

To make greater use of RNAV capabilities in terminal airspace, the FAA has begun to develop RNAV arrival and departure procedures for the top 50 airports. For major airports within 500 nm of each other (e.g., Phoenix and Las Vegas), the FAA is exploring the concept of city pair SID/STAR routes whereby the STAR would begin where the SID ends, and en route air traffic control services would not be required. To accommodate longer range en route RNAV flights, the FAA has modified software to allow the filing of RNAV routes. Some RNAV routes have already been implemented in the Caribbean.

## The National Route Program (NRP)

The NRP gives airlines and pilots increased flexibility in choosing their routes. NRP flights are not limited to published ATC-preferred routes; they are only subject to route limitations within a 200 nm radius of take-off or landing. This flexibility allows airlines to plan and fly the most cost-effective routes and increases the overall capacity and efficiency of the aviation system.

From January 1995 to November 1996, the NRP was expanded in ten phases, with each phase lowering the base altitude for participation. NRP operations are currently authorized at or above FL290 across the contiguous United States. Participation has increased with the implementation of each phase. In October 1995, there were 600 NRP flights daily. By September 1997, the average had increased to more than 1,500 NRP flights daily. Participation rates are higher on longer flights. The FAA estimates that the NRP saved the aviation industry as much as $65 million in 1997, or about $150 per flight, by allowing pilots to fly more optimal routes.

In an effort to expand the NRP and increase participation rates, the FAA is planning to eliminate the 200 nm requirement through the use of SID/STAR routes as ingress/egress points to the NRP. In doing this, the user will be allowed to file a SID to join an NRP route and to exit an NRP route via a STAR. Twenty-four SIDs and 15 STARs in six airport areas (Kansas City, St. Louis, Denver, Minneapolis, Salt Lake City, and Philadelphia) will be included in initial implementation. The first implementation of SID/NRP/STAR procedures is scheduled for early 1998. Future efforts to augment the NRP will focus on expansion of the NRP to altitudes below FL290.

## Elimination of Unnecessary ATC-Preferred Routes

The FAA is striving to increase user routing flexibility by eliminating ATC-preferred routes where possible. ATC-preferred routes are important tools that help air traffic controllers organize traffic flows around major airports. There are currently 1,975 ATC-preferred routes. It is estimated that during a given day, pilots using the low altitude system (below 18,000 feet) add approximately 125,000 miles of extra distance to their flight plans as a result of published ATC-preferred routes. While it may never be desirable to eliminate all ATC-preferred routes, a recent audit indicates that at least 100-150 of these routes could be eliminated without negatively impacting system operations. In early 1998, the FAA plans to begin a six-month test phase in which these 100-150 ATC-preferred routes will be suspended. If no problems arise from the suspension of a particular ATC-preferred route, that ATC-preferred route will be eliminated. An additional 1,300 routes will be analyzed to assess whether they also can be eliminated. As additional candidates for elimination are identified, they will be added to the list of suspended routes, and undergo a six-month test phase before being eliminated.

### Improving Civilian Access to Special Use Airspace (SUA)

The FAA is working with the Department of Defense (DOD) and NAS users to develop procedures for allowing greater civilian access to SUA.

Commercial and general aviation (GA) users seek access to Special Use Airspace (SUA) when that airspace is not in use by the military. The FAA is working with the Department of Defense (DOD) and NAS users to develop procedures for allowing greater civilian access to SUA. For these procedures to be effective, more real-time information on SUA availability is needed. Providing civilian users with this information requires the development of software for recording SUA time and altitude availability, as well as procedures and software for ensuring that users have access to the data. An operational trial conducted within the Edwards R-2508 airspace complex demonstrated that improved information exchange on the status of SUA can increase civil aircraft use of these military areas. During the operational trial, one airline saved approximately $180 per flight due to direct routing through the SUA, a monthly savings of $30,000. Due to the successful operational trial, the FAA has continued to disseminate SUA information on a real-time basis and allow flights to file flight plans that transverse the Edwards R-2508 airspace complex when it is not in use by the military. Figure 5-1 illustrates areas designated as SUA in the continental United States.

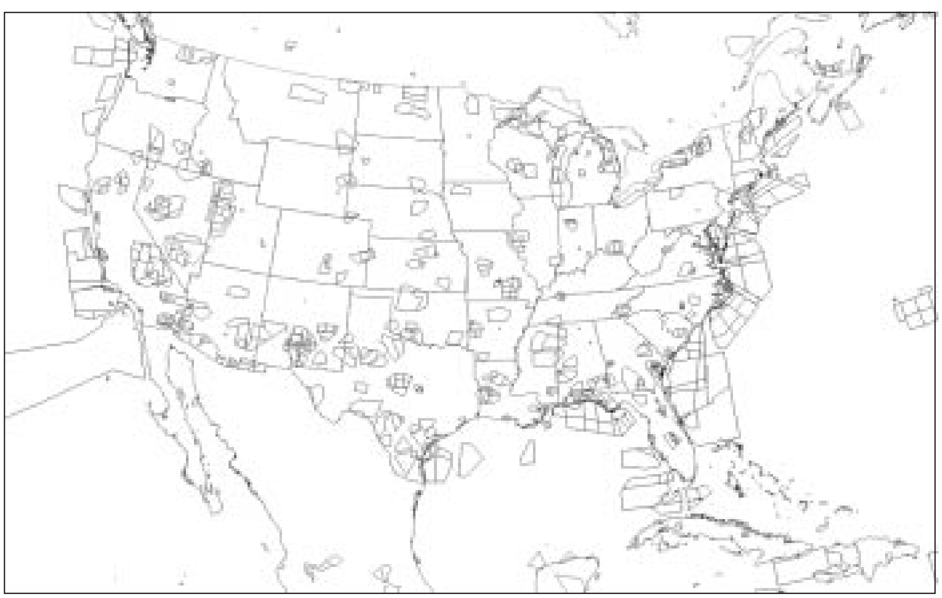


**Figure 5-1.**

SUA in the Continental United States

Information sharing between the military and the FAA on SUA availability has also increased capacity in other areas. For example, Southern California Terminal Radar Approach Control (TRACON) has developed a departure through an SUA that reduces delays from Los Angeles; High Desert TRACON receives immediate notification when a nearby SUA is available and forwards this information to the users. The FAA's Alaskan Region has worked with the military to provide frequencies and a 1-800 telephone number for pilots to obtain current information on SUA availability. Additional initiatives to increase access to SUA include cooperative decision-making between the DOD and the FAA on which hours SUAs will be active and redefining the boundaries of some SUAs.

Additional initiatives to increase access to SUA include cooperative decision-making between the DOD and the FAA on which hours SUAs will be active and redefining the boundaries of some SUAs.

## New Guidelines for Imposing Restrictions

The use of air traffic restrictions is a tool by which air traffic controllers manage their workload, avoid congestion, and restrict aircraft movement during periods of severe weather. For example, during high volume arrival and departure periods, air traffic controllers may request that arriving aircraft maintain ten miles-in trail separation from the preceding aircraft to moderate traffic flow into the terminal area. Beginning in 1994, the FAA conducted several audits to measure the number and duration of restrictions and identify unnecessary restrictions. The initial audit showed 3,998 restrictions in effect for 8,229 hours. An audit performed one year later found a 28 percent reduction in the number of restrictions and a 34 percent reduction in the number of hours in which restrictions were in place. An audit in February 1996 yielded an additional 5 percent reduction in the number of restrictions and an additional 25 percent reduction in the number of hours in which restrictions were in place.

In June 1997, the FAA developed a procedure to prevent unnecessary traffic restrictions. In the past, facilities often imposed restrictions based on their recollections of prior traffic patterns. Under the new procedure, all requests for restrictions must be coordinated through the Air Traffic Control System Command Center (ATCSCC). Local facilities must do thorough testing and analysis of all options before calling ATCSCC with a request for a restriction. The ATCSCC will then analyze the options from a national perspective before discussing which option to implement. The decision to impose the restriction requires consensus between ATCSCC and the requesting facility. The result of the more stringent standard has been a further reduction in the number of restrictions, resulting in more efficient operations for the users.

## Oceanic En Route Procedures

A number of procedural initiatives are currently underway that will increase capacity in the oceanic airspace while maintaining or improving safety.

### Reduced Vertical Separation Minima (RVSM)

The goal of RVSM is to reduce the vertical separation between FL290 and FL410 from the current 2,000-feet minimum to 1,000-feet minimum.

Procedures implemented more than 40 years ago required a 1,000-feet minimum vertical separation between IFR aircraft below FL290 and 2,000-feet separation above FL290. The adoption of 2,000-feet separation above FL290 reflected the belief that altimeters in use at that time were less accurate at higher altitudes. Today, most aircraft are equipped with highly accurate altimeters. In response to the demand for more capacity, the FAA has begun a phased implementation of RVSM in the North Atlantic. The goal of RVSM is to reduce the vertical separation between FL290 and FL410 from the current 2,000-feet minimum to 1,000-feet minimum. Operational trials of RVSM began in the North Atlantic airspace from FL330 to FL370, inclusive, in March 1997. Expansion of the RVSM to FL310 and FL390 is planned for April 1998. Additional phases will lead to full implementation that will include FL290 and FL410. Implementation of RVSM should result in almost doubling available oceanic tracks across the North Atlantic within the relevant altitudes. Existing capacity constraints on optimum tracks and levels will be substantially reduced, and aircraft will be able to operate closer to optimum levels. Fuel savings from aircraft flying more optimum routes due to RVSM in the North Atlantic are projected to range from 13 to 18 million gallons annually, depending on traffic density. Based on the successful implementation of RVSM in the North Atlantic, users have requested RVSM in the Pacific as well. The FAA is now examining the feasibility of this initiative.

### Reduced Horizontal Separation Minima (RHSM)

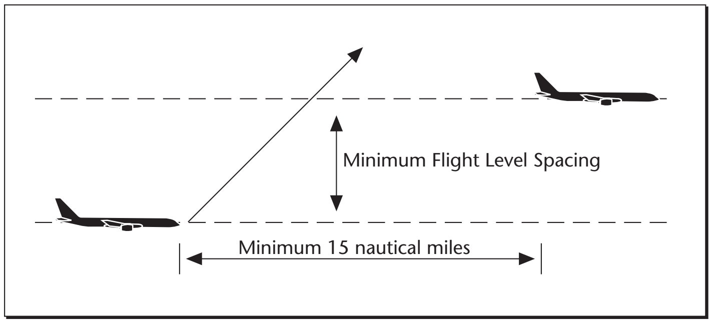
The current oceanic ATC system uses filed flight plans and position reports to track an aircraft's progress and ensure separation is maintained. The progress of an aircraft is monitored by ATC using position reports sent by the aircraft over high frequency (HF) radio. Position reports are infrequent (approximately one report per hour), and the accuracy of these reports depends on the accuracy of the on-board navigation system and timing standard aboard the aircraft. HF communication is subject to interference, disruption, and delay because it involves the use of radio operators to relay messages between pilots and controllers. These deficiencies in communications and surveillance have necessitated large horizontal separation minima.

As a result of improved navigational capabilities made possible by technologies such as GPS, TCAS, and controller to pilot data link communications (CPDLC), oceanic minimum horizontal separation standards, lateral and longitudinal, will be reduced. In the Pacific, lateral separation standards will be reduced from the current standards (60 nm to 100 nm depending on location) to 50 nm in specific oceanic areas in 1998. Where traffic density permits, longitudinal separation in the Pacific will be reduced from the current time-based standard of 15 minutes to 50 nm by late 1998. The reduced lateral separation minima will allow increased capacity during peak hours. The reduced longitudinal minima will provide increased opportunities for altitude changes to achieve optimum altitudes, thus saving fuel.

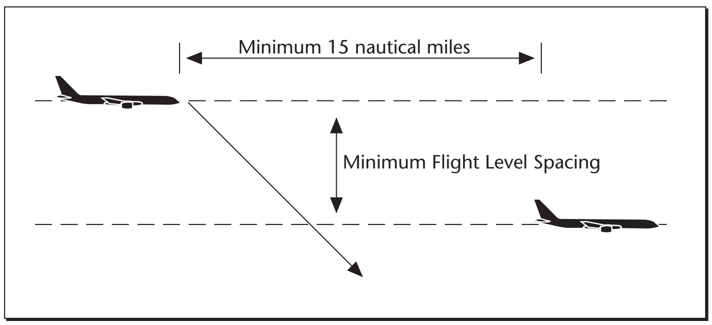
## In-Trail Climb (ITC) and In-Trail Descent (ITD)

The ITC and ITD procedures enable a trailing aircraft in a non-radar (oceanic) environment to climb or descend through the altitude of a leading aircraft to a more desirable cruising altitude. Using the ITC or ITD procedure, an aircraft flying behind and 2,000 feet above or below an aircraft along the same oceanic route may request to climb or descend through the altitude of the lead aircraft as long as the distance between them is at least 15 nm and the ground speed closure rate is 20 knots or less. The pilot wanting to ascend or descend uses the Traffic Alert and Collision Avoidance System (TCAS) traffic display (described in Chapter 6) to positively identify and determine the distance to the lead aircraft. The trailing aircraft initiates the procedure, coordinates with the lead aircraft, and obtains climb or descent clearance from ATC. ATC maintains responsibility for separation during the maneuver. Standard non-radar spacing criteria are applied by ATC after the procedure is completed. ITC and ITD are the first procedures to utilize the display of traffic information on the flight deck to assist air traffic controllers in monitoring and reducing aircraft spacing requirements. The ITC and ITD procedures reduce the typical non-radar in-trail distance necessary to approve a climb or descent from 10 minutes (approximately 100 nm) to a minimum of 15 nm. Without the benefit of this procedure the trailing aircraft may be trapped below the lead aircraft. The inability to gain a higher altitude significantly increases fuel burn.

Operational trials for the ITC procedure have been conducted in the Oakland and Anchorage Flight Information Regions (FIRs) since 1994 with United Airlines and Delta Air Lines. Data collected during the trials indicate that pilots and controllers find the procedure useful and are using it correctly, safely, and cooperatively. Both pilots and controllers have recommended adoption of this procedure. Based on these data, the next phase of operational trials will include six additional airlines—American, Air New Zealand, Canadian, Cathay Pacific, Hawaiian, and Singapore airlines. Figure 5-2 illustrates the ITC and ITD procedures.




In-Trail Climb




In-Trail Descent

**Figure 5-2.**

In-Trail Climb and In-Trail Descent

### Dynamic Aircraft Route Planning (DARP)

The DARP initiative provides the ability to update/revise a flight route while an aircraft or a group of aircraft is en route. This will allow a user to take advantage of a more efficient trajectory when a revised forecast is published by the traffic management unit (including real-time weather and winds information) in order to optimize the route of flight. An aircraft may take advantage of this trajectory for the remainder of its route, saving time and fuel. In 1997, the FAA began oceanic trials of the DARP between Los Angeles and Sydney.

## Terminal Area/Approach Procedures

There are a number of visual and electronic landing aids at or near airports that assist pilots in locating the runway, particularly during IFR weather conditions. Approach procedures have been developed based on the type and accuracy of landing aids available. Some of these approach procedures are discussed below.

## Area Navigation (RNAV) Approaches

With the capabilities enabled by RNAV technologies such as GPS and FMS, the availability and number of approach procedures to airports can be increased. GPS, unlike other RNAV technologies, is capable of providing precise vertical and horizontal guidance to a runway. This capability will enable the development of precision approaches during low weather minimums to airports not having precision landing aids today. By accelerating the publication of RNAV approach procedures, air traffic services (ATS) will increase access to the Nation's airports during IFR weather conditions. ATS plans to publish a minimum of 500 non-precision RNAV approaches per year over the next three years.

## Simultaneous Converging Instrument Approaches

Under existing approach procedures, converging runways can be used for independent streams of arriving aircraft only when the ceiling is at least 900 - 1,000 feet and visibility is at least three statute miles. This requirement decreases runway capacity in instrument meteorological conditions (IMC) and causes weather-related delays. Simultaneous approaches cannot be conducted under IMC if the converging runways intersect.

In an effort to refine the converging approach procedures and obtain greater operational efficiency for the users, the Converging Approach Standards Technical Work Group (CASTWG) was formed. The goal of the workgroup is to reduce landing minimums for aircraft conducting simultaneous converging instrument approaches, using FMS technology and new procedures to ensure required aircraft separation is provided in the event of a simultaneous missed approach.

The CASTWG developed and tested a new missed approach procedure using a 95 degree turn from the localizer course, which can be implemented at 650-feet minimums. The procedure requires flight testing and validation prior to initial implementation. Once the new 650-feet minimums are implemented, efforts to further reduce the minimums to as low as 500 feet will continue.

Average capacity gains using the new minimums with FMS positive missed approach guidance are expected to be 30 arrivals per hour. When the new procedure is used in conjunction with other approaches, annual delay savings of more than 12,000 hours are projected for Chicago O'Hare, one candidate for the new procedure.

Average capacity gains using the new minimums with FMS positive missed approach guidance are expected to be 30 arrivals per hour.

Figure 5-3 illustrates the missed approach for the new simultaneous converging instrument approach and lists candidate airports for the new procedure.

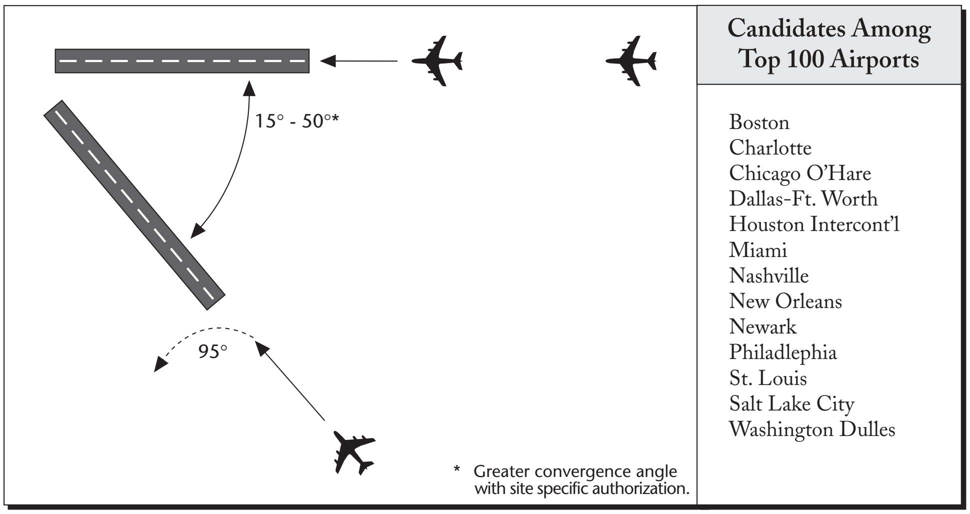



**Figure 5-3.**

Independent Converging Approach and Missed Approach Procedure

## Removal of 250 Knot Speed Limit for Departing Aircraft in Class B Airspace

Currently aircraft are restricted to a 250 knot speed limit below 10,000-feet mean sea level (MSL). This restriction constrains capacity by limiting departure rates. Laboratory simulations for St. Louis and Dallas/Fort Worth terminal areas indicated that removing the speed limit resulted in no major safety concerns, insignificant noise impacts, and no appreciable change in controller workload. In June 1997, the FAA began a field program at George Bush Intercontinental Airport, Houston International TRACON to determine the feasibility and impact of removing the 250 knot speed restriction for aircraft departing in Class B airspace. Under the field program, there are three test procedures. The first test procedure is to allow controllers to remove the 250 knot speed limit when operationally advantageous. The second test procedure will allow aircraft to exceed 250 knots after reaching a particular altitude. The third test procedure will allow aircraft to climb at an unrestricted speed at the pilot's discretion. Interviews with controllers and users conducted in August 1997 indicated that the flight crews were enthusiastic supporters of the concept, while controllers view their authority to remove restrictions as a valuable tool to enhance the efficiency of departure flow.

# Chapter 6: Capacity Enhancing Technologies

Over the next two decades, the FAA will introduce numerous technologies to the civil aviation system that promise to improve safety, increase capacity, reduce delays, provide greater flexibility and predictability, and improve the overall efficiency of the National Airspace System (NAS). Worldwide, civil aviation authorities and airspace users are adopting many of these technologies as part of the transition from traditional air traffic control (ATC)—a system based on radio communications, radar surveillance, and ground-based navigation—to a more flexible and efficient airspace management system using digital communications, satellite navigation, and advanced processors.

The technologies identified in this chapter were selected based on their projected benefits to airspace and airport capacity. While emphasis is placed on new and developing technologies, it is understood that many capacity improvements will also be gained from incremental upgrades to existing systems or new applications of existing technology. Technologies discussed in this chapter are described in more detail in the FAA's Capital Investment Plan (CIP), Plan for Research, Engineering, and Development (R,E&D), and NAS Architecture.

This chapter is divided into five areas: Communications, Navigation, Surveillance, Weather, and Air Traffic Management. For each area, the characteristics of the current system are described, followed by a description of planned enhancements and the key technologies that will make those enhancements possible. A table listing all of the currently funded capacity-enhancing technology projects is presented for each area.

## Communications

The exchange of information is vital to all flight operations. This is especially true for large commercial operations that require continual interaction with flight planning and ATC facilities to obtain information concerning weather forecasts, clearances, taxi instructions, expected delays, position reports, air traffic advisories, airport information, etc. Problems in the communication system, such as frequency congestion and interference, impact the overall efficiency of operations. Planned improvements to the communications systems will greatly improve the quality, clarity, and amount of information exchanged among and between aircraft and ground facilities.

### Current Communication Capabilities

In domestic airspace, information is typically transmitted and received using voiced air/ground ultra high frequency (UHF) and very high frequency (VHF) radio. As the number of aircraft operations has grown and the demand for information exchange continues to rise, frequency congestion has become increasingly problematic, especially within terminal airspace. This congestion limits the effectiveness of communication, increases controller/pilot workload, creates delays, and increases the likelihood of missed or misinterpreted information. Frequency congestion is largely a result of increased demand for the spectrum available to the FAA. Los Angeles, Chicago, New York, and Atlanta airspace are already out of available channels. By 2004 - 2007, the FAA will be unable to provide additional channel assignments.

In oceanic airspace, long-range air/ground communication is performed through third-party high-frequency (HF) radios—a communication system that is often hampered by lengthy delays and subject to atmospheric interference. The shortcomings inherent in the HF radio system make position reports and ATC approvals for routine pilot clearance requests (i.e., altitude changes for favorable winds) difficult to obtain due to uncertainties concerning the location of nearby air traffic.

## Planned Communication Enhancements

Limited spectrum availability is a major driving force in transitioning to digital communications.

Limited spectrum availability is a major driving force in transitioning to digital communications. Between now and 2003, the NAS will add digital communication capabilities through the expanded use of UHF and HF data link services. The FAA expects a spectrum recovery of 3.8 digital channels for each current analog channel. As a result, communication capabilities among aircraft and ground facilities will be enhanced to increase the volume of information being transmitted while minimizing frequency congestion, interference, delays, and misunderstandings. Data, especially in the form of text and graphical information, will constitute a much larger portion of all air/ground communications than today. Further, wireless information will be made more available as worldwide aeronautical communication networks are developed.

### Aeronautical Data Link System

The term data link refers to the overall system for entering, processing, transmitting and displaying information. Data link technology is designed to transmit and receive air/ground voice, alphanumeric, and graphic information. Although some commercial operators already use these technologies to alleviate frequency congestion and improve communications, current data link architecture is limited to alphanumeric information in terminal and airport environments.

Improvements planned for data link will expand and enhance communications on the airport surface and during all phases of flight, and will facilitate more accurate and reliable communications between flight crews in oceanic airspace. Expanded use of data link technologies in the cockpit will also increase the effectiveness of pilot and air traffic management collaborative decision making. Data link's ability to handle large volumes of data will allow for greater on-demand access to airport information; arrival, departure, and taxi schedules; airborne and surface surveillance information; NAS infrastructure status; and real-time weather information. This communication system will shift from analog to digital, make more use of satellites as a transmission media, and reduce congestion and frequency interference associated with today's analog-based communication systems. Specific data link projects include Ocean Data Link (ODL), which will greatly expand oceanic communications, and Controller to Pilot Data Link Communications (CPDLC), which will improve the speed and reliability of controller to pilot communications and contribute to overall NAS safety and capacity. Current data link services will be expanded between 2000 and 2005 to provide services in all phases of flight.

Improvements planned for data link will expand and enhance communications on the airport surface and during all phases of flight, and will facilitate more accurate and reliable communications between flight crews in oceanic airspace.

### Aeronautical Telecommunication Network (ATN)

An integral component of the data link system is the Aeronautical Telecommunication Network (ATN). The ATN is a worldwide data network intended to provide data communications connectivity among mobile platforms, airlines, and other companies that provide services. The ATN will allow a collection of dissimilar transmission networks and interconnecting computers to operate as a single, cooperative network. The goal is to provide full and flexible support for data communications between aviation end-users around the world—both fixed-based and mobile.

### Next Generation Air/Ground Communication System (NEXCOM)

The Next Generation Air/Ground Communication System (NEXCOM) will provide air/ground communications in support of safety-critical ATC services. This project will provide radio system equipment to satisfy the FAA's need to replace existing unmaintainable radios and increase the capacity of the VHF spectrum. When fully operational, NEXCOM will:

- Provide air traffic controllers with the ability to accommodate the growing number of sectors and services using the available, limited radio frequency spectrum;

- Reduce logistical costs by replacing expensive to maintain VHF and UHF radios;
- Provide new data link communications capability to all user classes;
- Reduce air/ground radio frequency interference and provide security mechanisms to identify unauthorized users; and
- Recover critically needed VHF channels through improved spectrum utilization.

NEXCOM will meet the needs of the increasing number of NAS users and will satisfy the current and identified future requirements that cannot be met using the current voice communications system. Based on the VHF digital link standards defined by the International Civil Aviation Organization (ICAO), the new digital radio system will permit rapid failure detection and recovery to meet air/ground service availability requirements. It will also provide compatible interfaces with voice switches and aeronautical telecommunications network elements at control facilities. An investment decision is expected by March of 1998, and initial operational capability is expected in 2005.

Table 6-1 identifies and describes communications programs and technologies that will contribute to capacity enhancement. The projects are listed with CIP and R,E&D identification numbers for reference purposes.

## Navigation

Aviation navigation systems in use today vary considerably in terms of accuracy, coverage, and capabilities. The current navigational airways structure and most approach and landing charts are designed principally around the geographic location and technical characteristics of ground-based navigational aids. Future initiatives will enhance the current navigation system by using a more flexible and available satellite-based system.

### Current Navigation Capabilities

The primary means of aircraft navigation in the United States today is the VHF omnidirectional range (VOR) — a system made up of a series of ground stations that broadcast directional signals. These signals are used by aircraft to determine bearings to or from VOR stations. If the VOR and aircraft are equipped with Distance Measuring Equipment (DME), the signals can also be used to determine the distance to VORs. Navigating using VORs typically consists of flying airways (specific radials connecting VOR stations). The location of VOR stations often leads to indirect, inefficient flight paths between an aircraft's origin and destination.

## Table 6-1.

### Communications Enhancement Programs

| Program | CIP/R,E&D Plan Number | Facility/Civil Aviation System Component(s) Affected | Program Purpose/ Expected Capacity Benefits |
|---|---|---|---|
| Voice Switches | C-05 | Airport, Terminal, En Route | This project will provide modern voice switching equipment for terminal radar approach control (TRACON) facilities, large consolidated TRACON facilities, and airport traffic control towers. The new voice switching capabilities will enable air traffic controllers to communicate with aircraft and each other to manage traffic flows. |
| FAA Telecommunications Satellite (FAATSAT) | C-15 | Flight Service Stations, Terminal, En Route/Oceanic | This project provides the FAA with a leased service and a diverse, alternative path for primary interfacility telecommunications circuits–with the goal of avoiding single points-of-failure. It will be a cost-efficient way to meet NAS service availability and message quality requirements. |
| Aeronautical Data-link System (ADLS) | C-20 | Airport, Terminal,<br>En Route/Oceanic | ADLS will develop the hardware and software needed for non-critical<br>air traffic control communications between pilots and air traffic controllers, provide en route applications, and implement controller-to-pilot data link communications. This will improve pilot accessibility to information, relieve congested voice frequencies, and reduce the workload of pilots, specialists, and air traffic controllers. |
| Next-Generation Air/Ground Communications System (NEXCOM) | C-21 | Flight Service Stations, Airport, Terminal, En Route/Oceanic | This program will design, implement, and install a new air/ground radio communications system. It will replace obsolete, unmaintainable analog controller-to-pilot radios with multimode radios having digital voice and data link capability, provide new information exchange functions, and increase very high frequency (VHF) band spectrum use. |
| Aeronautical Data Link Communications and Applications | 031-110 | R,E&D, En Route, Oceanic, Terminal, Airport | This project will develop and validate domestic and international data communications standards associated with the Aeronautical Telecommunications Network (ATN) and special purpose air/ground data link capabilities. The two major elements of this Data Link program are communications and applications. The communications element includes the development of the automatic dependent surveillance broadcast (ADS-B) concept; concurrently, the key enabling applications to permit efficient flight crew to controller communications will be developed. The enhanced ATN communications capabilities provided by data link will facilitate improved airspace utilization and reduced delay and operating expenses. |
| Satellite Communications Program | 031-120 | R,E&D, En Route, Oceanic, Terminal, Airport | This project will develop the standards and perform required testing to support mobile satellite communication (SATCOM) operational use as an oceanic subnetwork to the ATN. This program is integrated with the Aeronautical Data Link Communications and Applications and the Oceanic Air Traffic Automation R,E&D programs to achieve increased safety, help reduce separation standards, and provide direct, reliable communications in the oceanic and remote areas. |

However, some avionics are capable of interpreting VOR and/or DME signals to provide Area Navigation (RNAV), allowing for more direct routing of flights. Most new air carrier and similarly equipped aircraft have a flight management system (FMS) with multiple DMEs that improve RNAV VOR accuracy.

Landing navigational systems are similar to and in some cases the same as en route systems. Landing aids are classified as precision and non-precision. Precision landing aids refer to systems that can, with a high degree of accuracy, align an aircraft's vertical and horizontal path with a runway to allow for low visibility landings. The Instrument Landing System (ILS) is the primary system used for precision navigation today. The capabilities of ILS systems are defined in three categories, with Category I being the least accurate and Category III being the most accurate. Non-precision landing aids typically refer to the use of en route navigational aids or a limited component of precision aids (e.g., ILS localizer only), to place aircraft within the proximity of a runway, allowing for a visual approach to landing.

## Planned Navigation Enhancements

The satellite navigation system in use today will become more accurate and available and have greater integrity. Current capabilities will be further augmented by ground facilities that will allow for precision guidance to landing, thereby expanding the number of precision approaches available during instrument meteorological conditions.

### Global Positioning System (GPS)

An alternative to land-based navigation and inertial guidance systems for both en route and terminal environments is the satellite-based U.S. Global Positioning System (GPS). The GPS system was developed by the military and has been in use by civil aviation since the early 1990s. Currently, the GPS system consists of a 24 satellite constellation, plus associated ground-based monitoring and control facilities. The satellites transmit precisely timed signals coded so that a receiver on or near the surface of the earth can calculate position information. The system is accurate, easy to use, and provides worldwide coverage. GPS also gives horizontal and vertical position information, a capability lacking in ground-based navigational aids (with the exception of certain precision landing aids). These combined attributes allow for more flexible arrival, departure, and low altitude random direct routes; reduced separation standards; precision approach and missed approach guidance to all runways; and streamlined procedure and naviga-

An alternative to land-based navigation and inertial guidance systems for both en route and terminal environments is the satellite-based U.S. Global Positioning System (GPS).

tion techniques. GPS has been extensively tested and is already being used as a primary means of navigation in the oceanic environment.

### GPS Wide Area Augmentation System (WAAS)

The Wide Area Augmentation System (WAAS) is an augmentation of GPS that includes integrity broadcasts, differential corrections, and additional ranging signals. It is being developed to provide the accuracy, integrity, availability, and continuity required to support all phases of flight through Category I precision approaches. WAAS consists of a network of wide area ground reference stations that receive and monitor the GPS signals. Data from these reference stations are transmitted to master stations, where the validity of the signals from each satellite is assessed and wide area corrections are computed. These validity (integrity) messages and wide area corrections also act as additional sources of GPS ranging signals, giving the user a direct verification of the integrity of the signal from each satellite in view. The system is scheduled to reach its initial operational capability in 1999. Additional satellites and ground stations will be added to enable it to serve as a primary system for air navigation and precision landing capabilities for Category I operations in 2001.

### GPS Local Area Augmentation System (LAAS)

The Local Area Augmentation System (LAAS) is an augmentation of GPS that will be needed for operations down to CAT II/III precision landing minimums. This system relies upon a precisely surveyed ground station within the terminal area to calculate differential correction and integrity information, which it then transmits to aircraft within line-of-sight coverage, typically providing an operational radius of up to 25-30 nautical miles. One LAAS system can provide service for multiple runways as long as they are within the LAAS operational range. LAAS can also provide terminal navigation, airport surface navigation, and guided missed approach and departure procedures. Minimum operating performance standards are scheduled to be completed by the middle of 1998; validation testing is scheduled to be completed by the end of 2001. By making precision approach procedures available to more airport runways and extending precision navigation to the airport surface, the LAAS will improve the safety and capacity of airports and surrounding airspace.

By making precision approach procedures available to more airport runways and extending precision navigation to the airport surface, the LAAS will improve the safety and capacity of airports and surrounding airspace.

Table 6-2 identifies and describes navigation programs and technologies that will contribute to capacity enhancement. The projects are listed with CIP and R,E&D identification numbers for reference purposes.

## Table 6-2.

### Navigation Enhancement Programs

| Program | CIP/R,E&D Plan Number | Facility/Civil Aviation System Component(s) Affected | Program Purpose/ Expected Capacity Benefits |
|---|---|---|---|
| Instrument Landing System (ILS) | N-03 | Airport | This program will establish new Category I (CAT I) ILS installations and provide operations and maintenance funding to sustain existing CAT I Mark-IA ILS installations until global positioning system (GPS) precision approaches are available. |
| Runway Visual Range (RVR) | N-08 | Airport | This program establishes new generation runway visual range systems to support precision landing operations and airport capacity enhancements. It also provides advanced microprocessor technology, remote maintenance monitoring capability, and resistance to poor weather conditions. |
| Augmentations for the Global Positioning System (GPS) | N-12 | Airport, Terminal, En Route/Oceanic | This program enables the satellite-based GPS to function as the single FAA radio navigation system for all oceanic and domestic phases of flight. Two specific projects involved in this program are the Wide Area Augmentation System (WAAS) and the Local Area Augmentation System (LAAS). WAAS will provide a wide area network of precisely located monitors, reference stations, master control stations, leased satellites, and ground uplinks. LAAS will augment GPS to allow precision runway approaches in geographical areas not covered by WAAS. GPS will reduce the interdependency of proximate airports by improving an airport's surrounding airspace capacity. |
| Satellite Navigation System | 032-110 | R,E&D, En Route/Oceanic, Terminal, Airport | This program will develop augmentations to navigation satellites (e.g., GPS) to support techniques, procedures, and standards to meet all civil aviation navigation needs. Satellite navigation presents opportunities for standardized worldwide civil aviation operations using a common navigation receiver and for significant improvements in safety, capacity, service, flexibility, and operating costs. |

## Surveillance

Knowing the position and intended path of aircraft relative to other aircraft — both on the ground and in the air — is necessary to ensure safe separation. The accuracy and certainty with which aircraft positions can be tracked determines the procedures and spacing allowed to maintain safe operations. Enhancing surveillance improves the efficiency of airspace usage by reducing separation requirements. In order to realize reduced separation standards, the free flight concept imposes particularly high demands on the ability to accurately and reliably locate and track the movement of aircraft with greater precision and a faster update rate than is used today.

### Current Surveillance Capabilities

Separation is ensured today by visual confirmation, radar imaging, and pilot position reports. Visual separation is common in both general aviation and commercial air transport operations, though its use is limited to clear weather conditions. Radar imaging allows air traffic controllers to see a wide view of aircraft movements and makes possible the task of monitoring and sequencing large numbers of aircraft. Pilot position reports are used particularly in areas where radar coverage is poor or absent and where visual contact cannot be assured.

In order to realize reduced separation standards, the free flight concept imposes particularly high demands on the ability to accurately and reliably locate and track the movement of aircraft with greater precision and a faster update rate than is used today.

### Planned Surveillance Enhancements

Surveillance coverage and accuracy will be enhanced by incorporating aircraft navigation information with existing radar. This information will be translated into 4-D (four dimensional - position plus time) position information and made available to pilots and controllers to enhance situational awareness, improve the efficiency of aircraft spacing, allow for greater route flexibility, and heighten conflict avoidance capabilities.

#### Automatic Dependent Surveillance (ADS)

To augment existing surveillance procedures and radar, a new system known as Automatic Dependent Surveillance (ADS) will be used. Unlike radar, which tracks aircraft using interrogating radio signals, ADS transmits position reports based on onboard navigational instruments. ADS relies on data link technologies to transmit this information. Presently there are two forms of ADS: ADS-Address (ADS-A) and ADS-Broadcast (ADS-B). The ADS-A system exchanges point-to-point information between a specific aircraft and air traffic management facility upon request; the

ADS-B system broadcasts information periodically to all aircraft and all air traffic management facilities within a specified area. The primary objective of ADS-A and ADS-B technology is to improve surveillance coverage, particularly in areas having poor or no radar coverage.

In the oceanic environment, where separation is now maintained through pilot position reports, the use of ADS will have a particularly beneficial impact.

When ADS-equipped aircraft are within radar coverage, their positions will be verified by radar reports, providing independent and redundant surveillance. In areas not covered by radar, ADS will allow separation requirements for participating aircraft to be reduced from current procedural separation standards, providing greater capacity and increased approvals of user preferred routes and altitudes. In the oceanic environment, where separation is now maintained through pilot position reports, the use of ADS will have a particularly beneficial impact. Optimum altitudes and speeds will be achieved through the expanded use of oceanic in-trail climb and descent procedures and aircraft will have the flexibility to change routes mid-flight if winds are not as forecasted. Because separation requirements will be reduced, more efficient merging of traffic from multiple oceanic tracks onto arrival routes will be possible.

On the airport surface, ADS will be used to assist in taxi operations. ADS-equipped aircraft will be displayed directly to flight crews and air traffic controllers on an appropriate overlay map. This capability will give the flight crew information to better evaluate the potential for runway and taxiway incursions, especially at night or in poor visibility, than is available today. The FAA plans to add ADS-A capabilities in Oakland and New York oceanic airspace in the year 2000. Initially, ADS-B will enable aircraft-to-aircraft transmission of position information from GPS, aircraft identification, and intent information. With deployment of STARS and replacement of the Host computer, the FAA can begin to receive ADS-B reports for display to the controller. The FAA will initially use interrogation of the aircraft to receive the ADS-B information, then add additional ground stations to increase surveillance coverage. A fully operational ground system is not scheduled until 2008.

Table 6-3 identifies and describes surveillance programs and technologies that will contribute to capacity enhancement. The projects are listed with CIP and R,E&D identification numbers for reference purposes.

## Table 6-3.

### Surveillance Enhancement Programs

| Program | CIP/R,E&D Plan Number | Facility/Civil Aviation System Component(s) Affected | Program Purpose/ Expected Capacity Benefits |
|---|---|---|---|
| ASDE Radar and Airport Movement Area Safety System (AMASS) | S-01 | Airport | The ASDE-3 provides radar surveillance of aircraft and airport service vehicles at selected airports to ensure an effective mode of directing and moving surface traffic. AMASS provides visual and aural alerts to potential and actual surface conflicts. When combined, ASDE-3 and AMASS provide a near-term solution to prevent runway incursions. |
| Mode S, Secondary Surveillance | S-02 | Airport, Terminal, En Route/Oceanic | Mode S will improve the surveillance capability of the air traffic control radar beacon system (ATCRBS). It provides more accurate positional information and minimizes interference. The program replaces aging and obsolete air traffic control beacon interrogator (ATCBI-4/5) equipment with a new mono-pulse secondary surveillance radar (MSSR) system. |
| Multilateration Technology | S-02/S-08 | Airport | The purpose of this project is to provide a demonstration prototype of the multilateration approach to monitoring final approaches to parallel runways. The multilateration approach represents a low-cost alternative to prescision runway monitor (PRM) that uses multiple air traffic control radar beacon (ATCRB) transponders and Mode S to provide accurate surveillance capability for monitoring final approaches to closely spaced parallel runways. |
| Terminal Radar (ASR) Program | S-03 | Airport, Terminal | This program replaces obsolete, logistically unsupportable airport surveillance radars with modern digital equipment compatible with the standard terminal automated radar system (STARS) and upgrades en route and secondary surveillance radars. |
| Long-Range Radar Program (LRR) | S-04 | En Route/Oceanic | This project will provide a national radar surveillance network by installing the air route surveillance radar at existing and new sites. It will improve the current inventory of long-range radars that will extend their useful life and/or aid the transition to a beacon-only en route surveillance system. |
| Precision Runway Monitor (PRM) | S-08 | Airport | This project developed a high-up-date-rate radar and computer predictive displays that reduce the allowable runway spacing for conducting independent parallel instrument approaches at closely-spaced runways. Conducting independent approaches will enable airports to increase throughput capacity, reduce delays, and save fuel during reduced visibility. |

## Weather

Weather is the single largest contributor to delay in the civil aviation system and is a major factor in aircraft safety incidents and accidents. Short-term forecasts and timely, accurate weather information on hazardous weather are critical to ensure safe flight and to plan fuel and time-efficient flight plans.

Weather is the single largest contributor to delay in the civil aviation system and is a major factor in aircraft safety incidents and accidents.

Many of the inefficiencies in today's weather system can be attributed to limitations in the accuracy, predictability, analysis, transmission, coordination, and display of weather data. To mitigate these issues, the FAA will incorporate technologies and procedures to improve the dissemination of consistent, common, and timely aviation weather information in graphical format to all users of the aviation system, both ground and airborne. Further, weather information will be improved through the use of better sensors, sophisticated computer modeling, and new automated systems.

### Current Weather Capabilities

The timeliness and reliability of weather information available to pilots and air traffic controllers is largely determined by the degree of communication and coordination among the many organizations and systems that gather and disseminate that information. The technical systems used to gather, report, and forecast weather range from obsolete to state-of-the-art. The weather systems in use today can be characterized as good in predicting large area forecasts (e.g., movement of fronts) but less capable of predicting the exact timing, location, and severity of local phenomena (e.g., thunderstorms).

### Planned Weather Enhancements

The FAA is working in conjunction with other agencies such as NASA and the National Oceanic and Atmospheric Administration to improve NAS capacity though better forecasting, detection, and dissemination of adverse weather conditions.

The FAA is working in conjunction with other agencies such as NASA and the National Oceanic and Atmospheric Administration (NOAA) to improve NAS capacity though better forecasting, detection, and dissemination of adverse weather conditions. Other weather-related technology enhancements include new information systems designed to integrate a wide range of weather data into a single database where it can be analyzed using new models. The output of these analytic tools will be displayed in the form of enhanced graphics on new display systems in ATC facilities and in the aircraft cockpit. The data link system will be an essential element in the timely dissemination and coordination of weather information to flight crews.

### Integrated Terminal Weather System (ITWS)

The Integrated Terminal Weather System (ITWS) is a fully-automated weather-prediction system that will give air traffic personnel and pilots enhanced information on weather hazards in the airspace within 60 nm miles of an airport. When fully implemented, ITWS will have the capability to generate predictions of weather phenomena such as microbursts, gust fronts, storm cell movements, and runway winds up to ten minutes in advance. Additionally, the system will display weather data in tower cabs, terminal radar approach control facilities, and their associated air route traffic control centers to facilitate coordination among air traffic control personnel. This system is a step toward avoiding delays caused by localized, hazardous weather and will increase the margin of safety. In addition, ITWS will improve traffic flow due to earlier warnings of weather impacts to an airport.

When fully implemented, ITWS will have the capability to generate predictions of weather phenomena such as microbursts, gust fronts, storm cell movements, and runway winds up to ten minutes in advance.

### Weather and Radar Processor (WARP)

Meteorologists working in the weather units of ATC centers do not have an integrated system for collecting and displaying multiple weather sensor inputs. The Weather and Radar Processor (WARP) will collect and process weather data from Low Level Windshear Systems (LLWAS), Next Generation Weather Radar (NEXRAD), Terminal Doppler Weather Radar (TDWR) and surveillance radar, and disseminate this data to controllers, traffic management specialists, pilots, and meteorologists. WARP will also provide meteorologists with automated workstations that improve their ability to analyze rapidly changing weather conditions. By providing a mosaic of weather information to advanced display systems, the WARP will assist air traffic management in minimizing weather-related delays.

Table 6-4 identifies and describes weather programs and technologies that will contribute to capacity enhancement. The projects are listed with CIP and R,E&D identification numbers for reference purposes.

## Table 6-4.

### Weather Enhancement Programs

| Program | CIP/R,E&D Plan Number | Facility/Civil Aviation System Component(s) Affected | Program Purpose/ Expected Capacity Benefits |
|---|---|---|---|
| Automated Weather Observing System (AWOS) | W-01 | Flight Service Stations, Airport, En Route/Oceanic | AWOS processes aviation-critical weather data from automated sensors and disseminates information to pilots by computer generated voice radio transmissions. The connection of AWOS with the automated weather observation system data acquisition system (ADAS) will make current weather observation data accessible to pilots and controllers, enhancing safety and efficiency. |
| Weather Radar Program (NEXRAD) | W-02 | En Route/Oceanic | NEXRAD provides a national network of Doppler weather radars to detect, process, distribute, and display hazardous weather information. Automated ATC capabilities, such as preferred routing and improved flow management, will require this type of accurate aviation weather data for en route applications. |
| Terminal Doppler Weather Radar (TDWR) System | W-03 | Airport, Terminal | This program involves the installation of a new terminal Doppler weather radar that can detect microbursts, gust fronts, wind shifts, and precipitation. It will warn aircraft in the terminal area of hazardous weather conditions and of changing wind conditions to enable the timely change of active runways. |
| Weather and Radar Processor (WARP) | W-04 | En Route/Oceanic | The WARP will collect, process, and disseminate weather information from next generation weather radars (NEXRAD) to air traffic controllers, traffic management specialists, pilots and meteorologists. By providing a mosaic product of NEXRAD data to the Display System Replacement (DSR), the WARP will enhance the quality of weather information available to air traffic controllers, thus reducing accidents and air traffic delays. It also provides center weather service unit/ central flow weather service unit meteorologists with automated workstations that improve their ability to analyze rapidly changing weather conditions. |
| Low-Level Windshear Alert System (LLWAS) | W-05 | Airport | The LLWAS provides local controllers and pilots with information on microbursts and windshear near airports. This program will increase the probability of microburst and windshear detection through system expansion and upgrades. Planned upgrades will refurbish the LLWAS system to make it logistically supportable for at least 15 years. |

## Table 6-4.

### Weather Enhancement Programs

| Program | CIP/R,E&D Plan Number | Facility/Civil Aviation System Component(s) Affected | Program Purpose/ Expected Capacity Benefits |
|---|---|---|---|
| Integrated Terminal Weather System (ITWS) | W-07 | Terminal | The ITWS will integrate relevant weather data accessible in the terminal area and from in-flight aircraft to provide air traffic personnel with timely, near-term weather information and predictions in a clear graphical and textual form. This program will deploy ITWS product generators to 34 TRACONs. |
| ASR Weather Systems Processor | W-09 | Terminal | This program enhances the hazardous weather detection capability of an airport surveillance radar by developing and testing a modular data processing channel for automatic detection of windshear, thunderstorm microbursts, and gust fronts. The advancement provides airports ineligible for terminal doppler weather radars with windshear warnings. |
| Aviation Weather Analysis and Forecasting | 041-110 | Aircraft/Aircrew, Flight Service, Airport, Terminal, En Route, R,E&D | The integration of this project with other national research programs that focus on atmospheric mesoscale analysis and prediction problems will improve the understanding of weather's effects on aviation. An additional purpose is to concentrate research efforts on developing new algorithms, numerical weather analysis and prediction models, and methods to detect the impact from weather hazards. This research will significantly improve weather product and forecast quality, thus enabling aviation weather users to make effective strategic and tactical decisions for aviation operations. |
| Aeronautical Hazards Research | 042-110 | Aircraft/Aircrew, Terminal, En Route, R,E&D | Designed to improve safety, the project will collect data and analyze systems to validate technology for detecting hazards such as mountain rotors. The research will improve the operational capability to detect, monitor and alert flightcrews to aeronautical hazards. |
| Low Visibility Landing and Surface Operations (LVLASO) | NASa | Airport, Terminal | The goal is to improve the efficiency of airport surface operations for commercial aircraft operating in weather conditions to Category IIIB while maintaining a high degree of safety. |

## Air Traffic Management

Air traffic management requires gathering and processing large volumes of data to make effective decisions according to ever changing conditions. The development of automated decision support systems will improve the effectiveness of air traffic information and yield more efficient use of airspace.

As the volume of air traffic increases and as procedures allow greater pilot discretion, the efficient management and monitoring of air traffic will require the use of more advanced decision support systems.

### Current Automation/Decision Support Capabilities

Air traffic controllers today use a combination of procedures and automated systems to separate traffic. The decision support systems in use today, however, provide only limited assistance to air traffic controllers. Most routine decisions are made based on the training, experience, and judgment of the individual controllers who must follow a set of narrowly defined air traffic procedures. As the volume of air traffic increases and as procedures allow greater pilot discretion, the efficient management and monitoring of air traffic will require the use of more advanced decision support systems.

### Planned Decision Support Enhancements

Numerous technologies are being developed to ensure the efficient and effective collection, transfer, and display of information. Decision support systems will augment these initiatives by coordinating information (e.g., flight plans, weather forecasts, infrastructure status, traffic densities, etc.) from multiple ground, air, and space-based sources and processing this information to improve the effectiveness of tasks such as flight planning, traffic sequencing, conflict checking, and conflict resolution. The integration of these data provides the opportunity for new analytic tools that controllers and/or flight crews may use to plot fuel efficient routes, identify potential conflicts with other aircraft, or adjust routes during flight. Graphical output from these analytic tools will assist users in decision making. The tools will enable controllers throughout the system to simultaneously provide greater flexibility, reduce delays in congested airspace, and enhance overall safety.

#### Standard Terminal Automation Replacement System (STARS) and Display Replacement System (DSR)

The Standard Terminal Automation Replacement System (STARS) will replace outdated air traffic control computers with 21st century systems at nine large consolidated TRACONs and approximately 152 FAA and 60 DOD terminal radar approach control sites across the country. STARS will support radar target identification and separation, traffic and weather advisory services, and navigational assistance to aircraft. STARS will also provide safety functions such as conflict alert and minimum safe altitude warning. Improvements, such as improved weather displays, will be introduced on the STARS platform to support air traffic management decision support functionality. The FAA expects to have the first STARS operational by December 1998, with subsequent deliveries to the FAA and DOD facilities scheduled through 2007.

The STARS' counterpart for en route airspace is the Display System Replacement (DSR). DSR will provide air traffic controllers with a modern digital display system capable of processing and providing information in a fast, reliable manner. DSR will support a conflict probe capability.

### Collaborative Decision Making (CDM) - Build 1

Part of the larger Air Traffic Management Program (ATM), the Collaborative Decision Making (CDM) program was initiated in an effort to improve traffic flow management by establishing closer collaboration between the FAA and the airlines. By using automated systems to establish accurate pictures of real-time schedule information, the FAA will be better able to determine actual and projected traffic flow demands at major airports. As the NAS becomes more congested, the efficient use of resources will become more important to both the FAA and NAS users. This improved communication with the airlines will help to eliminate some ground delay programs (GDPs), reduce the scope and duration of other GDPs, and allow NAS users more flexibility in responding to airport arrival constraints.

By using automated systems to establish accurate pictures of real-time schedule information, the FAA will be better able to determine actual and projected traffic flow demands at major airports.

Build 1 of CDM consists of several components including: the Flight Schedule Monitor (FSM) software, which displays arrival information, monitors ground delay situations, measures ground delay performance, and provides traffic managers with a "what-if" analysis capability for projecting scenarios and arrival rates; the Ration-by-Schedule function, which uses the schedule defined in the *Official Airline Guide* (OAG) as the baseline for allocating arrival slots to NAS users; the Schedule Compression function, which moves participating flights into newly available slots, thereby compressing the departure schedule and reducing assigned delays; the Data Exchange capability, which enables the airlines and the command center to send and receive the real-time schedule and demand information; and Flow Management Decision Support Enhancements, which includes utility functions for both traffic managers and NAS users that are user-friendly and permit "what-if" analysis. All of these features facilitate information exchange between NAS users and air traffic service providers.

## Center Terminal Radar Approach Control Automation System (CTAS)

The CTAS will provide users with airspace capacity improvement, delay reductions, and fuel savings by introducing computer automation to assist controllers in efficiently descending, sequencing, and spacing arriving aircraft. CTAS will provide two major functional capabilities in the near term: single center traffic management advisor (TMA) and passive final approach spacing tool (pFAST). The TMA will provide en route controllers and traffic management coordinators with automation tools to manage the flow of traffic from a single center into selected major airports. It will result in estiamed delay reductions of one to two minutes per aircraft during peak periods. pFAST will help controllers select the most efficient arrival runway and arrival sequence within 60 nm of an airport, resulting in increased arrival throughput. The FAA is planning to implement TMA at 15 ARTCCs between the years 2002 and 2004, and pFAST at 22 TRACONs between 2002 and 2006.

Long term improvements for CTAS include: multi-center TMA capability, required when multiple ARTCCs meter arrivals into a single terminal; descent advisor, which will provide optimized descent point and speed advisories to controllers based on aircraft type; and active FAST, which will help controllers determine how to vector aircraft onto final approach.

## Initial Conflict Probe (ICP)

The Initial Conflict Probe will provide controllers with the ability to look ahead to identify potential separation conflicts with greater precision and accuracy. By estimating current position and predicted flight paths, ICP checks for potential loss of separation at current and future times. This system can be triggered automatically or manually.

The ICP display supports the strategic planning function and reduces the use by air traffic controllers of manual flight strips. Other potential benefits of ICP include conflict detection in oceanic airspace, greater route flexibility during weather changes, relaxed boundary restrictions, and more efficient routings provided well in advance of, rather than close to, the conflict. The FAA implemented the User Request Evaluation Tool, a prototype ICP, as a daily-use probe at the Indianapolis Center in 1997. It will be implemented at the Memphis Center in 1998. Field upgrades to ICP will also occur in 1998.

Table 6-5 identifies and describes automation/decision support programs and technologies that will contribute to capacity enhancement. The projects are listed with CIP and R,E&D identification numbers for reference purposes.

## Table 6-5.

### Decision Support System Programs

| Program | CIP/R,E&D Plan Number | Facility/Civil Aviation System Component(s) Affected | Program Purpose/ Expected Capacity Benefits |
|---|---|---|---|
| En Route Automation Program | A-01 | En Route/Oceanic | Projects in this program will replace aging and unsupportable equipment and allow continued system growth in the present ATC system, providing a safe and efficient air traffic environment that contributes to the move toward a free flight environment. |
| Tower Automation Program (TAP) | A-02 | Airport | The program will integrate new and existing safety systems in a consolidated automation platform with a common computer/human interface. TAP will solve the problems of controllers having minimal flexibility to rearrange operational positions for various tower operating conditions and the inefficient placement of individual control systems. |
| Automated Radar Terminal System (ARTS) Improvements | A-03 | Terminal | This program will provide contractor support for developing terminal software where the technical requirements exceed FAA in-house development capabilities. New and modified equipment will maintain or improve safety levels while increasing traffic capacity. |
| Standard Terminal Automation Replacement System (STARS) | A-04 | Terminal | This program reflects the long-term approach to improving the FAA's automation capabilities in the terminal environment. STARS will deploy a new automation system that uses a modern, commercially-open architecture that solves current capacity problems and supports future demands. |
| Traffic Management System (TMS) | A-05 | Airport, Terminal, En Route, Oceanic | This program develops and deploys integrated hardware and soft ware to accommodate modern computing and communications technology and provides an open-systems architecture for future functions. TMS will also develop and deploy collaborative decision-making and decision support tools for resolving NAS congestion. This program, also referred to as the Air Traffic Management (ATM) Program, will maximize air traffic throughput, minimize air traffic delays, and establish a reliable, serviceable automation platform. |
| En Route Software Development | A-06 | En Route/Oceanic | The program provides the necessary support for the continuing development, integration, and implementation of NAS en route software changes to correct operational problems and provide systems enhancement. |
| Flight Service Automation System (FSAS) | A-07 | Flight Service Stations | The FSAS replaces the FSAS model 1-full capacity (M1FC) and integrates M1FC functions with the integrated graphic weather display system (IGWDS) and the direct user access terminal system (DUATS). This will provide a flight service specialist with automated advancements that improve weather and Notice to Airmen (NOTAM) briefings and simplify flight plan filing. |
| Oceanic Automation Program (OAP) | A-10 | Flight Service Stations, En Route/Oceanic | The OAP will provide an automation infrastructure including oceanic flight data processing, a computer-generated situation display, and a strategic conflict probe for alerting controllers to potential conflicts hours before they occur. Ultimately, controllers will be able to grant more fuel-efficient flexible routes, which will significantly reduce fuel costs and delays. |
| Oceanic Air Traffic Automation | 021-140 | En Route, R,E&D | This project aims to increase oceanic air traffic capacity and efficiency without degrading safety. Research and development in this project will lay the foundation for new F&E initiatives leading to the introduction of free flight in oceanic airspace. |

## Table 6-5. (continued)

### Decision Support System Programs

| Program | CIP/R,E&D Plan Number | Facility/Civil Aviation System Component(s) Affected | Program Purpose/ Expected Capacity Benefits |
|---|---|---|---|
| Center Terminal Radar Approach Control (TRACON) Automation System (CTAS) Prototype | F-01, A-05 | Airport, Terminal | This program develops the prototype of the center terminal radar approach control facility automation system (CTAS). CTAS provides operational prototypes of the traffic management advisor (TMA) and final approach spacing tool (FAST) at air route traffic control center (ARTCC) and TRACON pairs. |
| Advanced Traffic Management System (ATMS) | 021-110 | Flight Service, Airport, Terminal, En Route | The ATMS has been reconstructed to focus on building collaborative decision making and decision support tools that will allow FAA traffic flow managers to work cooperatively with industry in responding to NAS congestion conditions. |
| Surface Movement Advisor (SMA) | 021-200 | Airport | The SMA will interface with and improve other NAS management systems and coordinate surface activities with ATC, the airlines, and airport operators through an unprecedented sharing of operation-ally-critical surface movement information. |
| Traffic Alert and Collision (TCAS) | 022-110 | Aircraft/Aircrew, Terminal, En Route | This project will develop and assist in implementing an independent airborne collision avoidance capability. TCAS will reduce midair collision risks and increase capacity by aiding simultaneous approaches to parallel runways and pilot-maintained in-trail spacing via the improved cockpit display capability. |
| Aviation System Capacity Planning | 024-110 | Airport, Terminal, En Route | The program supports development of an overall capacity strategy; the conduct, measurement, and assessment of airports and technologies; and development and application of electronic tools that aid in the formulation of that strategy to reduce delays, increase the number of operations per hour and to decrease maintenance and operating costs. |
| Airport Pavement Technology | 051-120 | Airport, R,E&D | Specific projects will be carried out to develop an integrated method for pavement design that will reduce pavement design and construction costs, minimize pavement failures, lower the costs of maintenance, and reduce pavement downtime and aircraft delay costs. The program will also develop a new pavement design procedure based on layered-elastic theory to support U.S. aircraft manufacturer's efforts to introduce new aircraft. |
| Airborne Information for Lateral Spacing (AILS) | NASA | Airport, Aircraft/Aircrew | AILS's goal is to enable "airborne technology assisted approaches" to safely reduce lateral spacing requirements during IMC. It will provide crew with information on nearby traffic comparable to that available in VMC. |